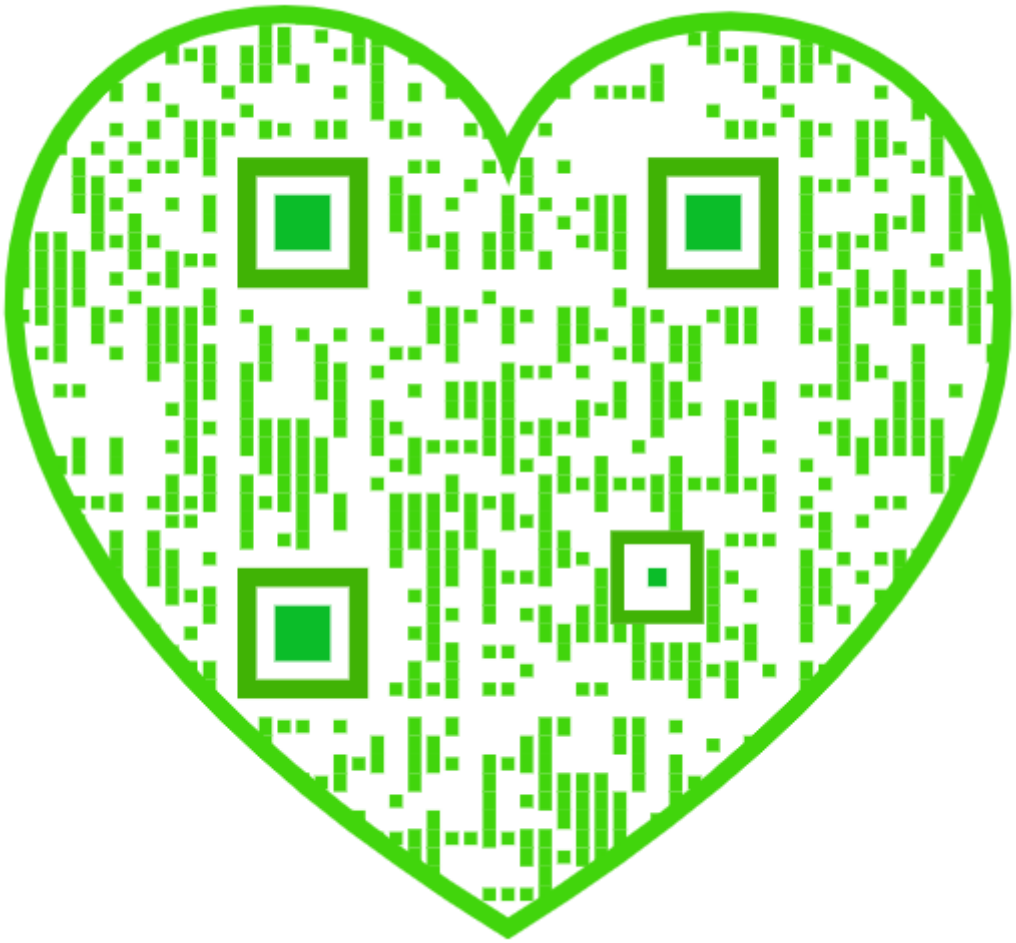

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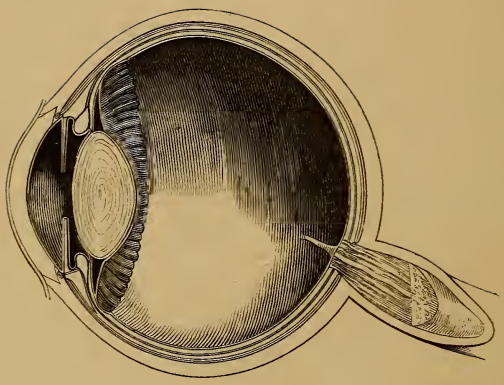

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Before entering upon the consideration of the physiology of the eye, it will be requisite briefly to state the chief facts connected with light, and the laws by which it is governed.

Two theories have been entertained respecting the nature of light. Newton imagined that there was a material substance emitted by all self-luminous bodies in extremely subtle particles, and moving in straight lines with great velocity, which, impinging upon the optic nerves, produced the sensation of light. Of late years, however, another theory has gained ground, and is now al-

most universally adopted. It is to the effect that all space is filled with an extremely elastic and rare ether, and that light is the result of undulatory movements communicated to this ether by self-luminous bodies; which undulatory movements being transmitted to the optic nerves, give rise to the sensation of light.

When a ray of light impinging upon a surface is thrown back into the medium in which it was moving, it is said to be *reflected*, and in such case the angle of incidence and the angle of reflection are always equal.

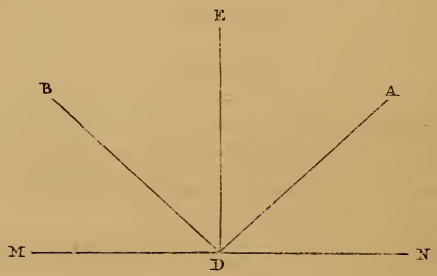

Fig. 1.

Let A D (Fig. 1) be a ray of light falling upon a plane speculum, M N ; at the point D, it will be reflected in the direction D B; and the angle B D E will be equal to the angle A D E.

The ray A D is called the *incident ray*, and B D the *reflected ray*; A D E the *angle of incidence*,

and B D E the *angle of reflection;* and a plane passing through A D and B D, or the plane in which these two lines lie, is called the *plane of incidence,* or the *plane of reflection.*

Light consists of rays of different colours and of different amounts of refrangibility.

By *a ray* of light is meant the thinnest imaginable stream emanating from a luminous body. Rays which recede from each other as they advance are called *diverging* rays. Those which approach each other as they proceed are termed *converging* rays.

The point to which rays converge is called their *focus,* or *focal point.*

That from which they proceed, their *radiant* or *radiating* point.

The distance of the focus from the reflecting or refracting surface is termed the *focal distance* or *focal length.*

The point from which rays, not originally parallel, appear to diverge, or towards which they appear to converge, whether from reflection or refraction, is called a *virtual* focus.

The point to which parallel rays are reflected or refracted, is denominated the *principal* focus.

When a ray of light passes out of one medium into another, and has its direction changed at

the common surface of the two media, it is said to be *refracted*.

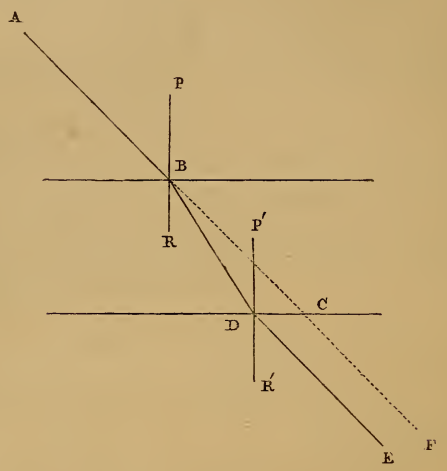

Fig. 2.

Let A B (Fig. 2) represent a ray of light passing through air, and incident obliquely on the surface of water at B. Instead of pursuing its original course to C, it will be refracted in the direction B D, and drawn *towards* P R, a line perpendicular to the surface of the water at the point of incidence B. If the dense medium is bounded by plane surfaces, parallel to each other as represented; on quitting the dense medium, to enter one which is less dense, as air, the ray will

undergo a second and opposite refraction. The ray B D, quitting obliquely the second surface of the dense medium, is refracted *from* the perpendicular P′ R′, and takes the direction D E, which is parallel to C F, the original course of the ray.

Light, then, passing obliquely from a rare into a dense medium,* as from air into glass, is bent or refracted from its course *towards* a line perpendicular to that point of the denser surface where the light enters it. But where it passes obliquely from a dense into a rare medium, as from glass into air, it is refracted in a direction *from* that perpendicular.

Refraction is always accompanied by some degree of reflection. There is no substance known which is perfectly opake or perfectly transparent; charcoal, the most opake of bodies, in a different state of aggregation as diamond, is one of the most perfectly transparent. Gold may be beaten so thin, as to be pervious to light, and the purest air or clearest water gradually extinguishes by absorption, the rays which are transmitted through it. Thus it is, that objects at the bottom of very deep water are

* The refracting power and the density of a substance, do not always travel together. The diamond has greater refracting power than some other substances more dense.

invisible, and more stars are seen from the summit of a very lofty mountain than from a less altitude; because the light from the most distant stars becomes so much enfeebled by its passage through the lower atmospheric strata, that it has not sufficient power to affect the sight.

Waves of light, (like those of sound,) are transmitted in every direction from a luminous body, and their intensity is inversely as the square of the distance. The velocity of light (or more strictly speaking, of the luminous undulations) is about a *hundred and ninety-two thousand miles in a second.* Although the progressive motion of light is uniform and in a straight line, the vibrations of the particles are always at right angles to the direction of the line.

The compound nature of white light was proved by Sir Isaac Newton, by passing a sunbeam through a prism, which separating the rays by refraction, gave rise to the formation of a spectrum consisting of seven colours—viz. red, orange, yellow, green, blue, indigo, and violet, all possessed of different degrees of refrangibility; the red being *least* refrangible, the violet the *most* so. Finding by experiments that each coloured ray was incapable of further decomposition, Sir Isaac concluded that white light con-

sisted of seven kinds of homogeneous light. Sir David Brewster, however, has proved by a variety of ingenious experiments that the solar spectrum consists of *three* primary colours, red, yellow, and blue, each of which exists throughout the whole extent of the spectrum, but with different degrees of intensity in different parts; and that the super-position of these three produces all the seven hues according as each primary is in excess or deficient.

The proportion of each colour in the spectrum, according to the observations of Newton and of Fraünhofer, is as follows:

	Newton.	Fraünhofer.
Red	45	56
Orange	27	27
Yellow	40	27
Green	60	46
Blue	60	48
Indigo	48	47
Violet	80	109
	360	360

Besides the seven colours ordinarily described, it would appear from Sir J. Herschell's experiments, that there is just beyond the violet a band

of coloured light of still greater refrangibility; it has been denominated the *Lavender* band.

Colours are frequently supposed to be certain properties inherent in substances.* In reality, colour is not a property of matter, but arises from the action of matter upon light, and depends simply upon such an arrangement of the constituent particles, that certain of the coloured rays which help to form white light, are reflected, whilst the others are absorbed or transmitted.

Bodies that reflect all the rays appear *white*, those that absorb all, *black*, but the generality of substances absorb some and reflect others. Scarlet cloth absorbs almost all the colours, except the red, which it reflects. In like manner, blue cloth reflects the blue rays, and absorbs the rest.

The colour of transparent substances depends upon their property of absorbing some of the colours of white light, and transmitting others. The rich dark light transmitted by blue smalt glass is composed of all the colours of white light, minus those which have been absorbed by the glass. All tints are the most brilliant when viewed in light of their own colour; for instance, the hue of scarlet cloth is infinitely more intense

* Appendix A.

when viewed in red light, and a blue ribbon is much more vivid in blue light than in white.

Sir W. Herschell discovered that there are rays in the solar spectrum which give rise to the sensation of heat, independently of those of light. Perhaps their vibrations are not of sufficient velocity to communicate to the retina the sensation of light; so that it is only by their calorific properties that we are cognisant of them.* These calorific rays are most abundant a little beyond the red extremity of the spectrum, and gradually diminish towards the violet, beyond which they are imperceptible.

Dr. Wollaston made the discovery that rays known only by their chemical action, exist beyond the extreme violet: it is probable that the rapidity of the undulations of these rays is too great to make an impression upon the retina, so that it is by their chemical effects alone that we are made acquainted with their existence: these effects are seen in the fading of vegetable colours and the blackening of nitrate of silver. It has been demonstrated beyond a doubt, that the coloured rays in the solar spectrum differ materially, not only in their refrangibility, but also

* Appendix B.

in the length and rapidity of their undulations. The following table, which has been most carefully constructed by Sir. J. Hershell, shows this. The subject is of much importance, and I shall have occasion to revert to it again.

Coloured Rays.	Length of luminous waves in parts of an inch.	Number of undulations in an inch.	Number of undulations in a second.
Extreme Red	0.0000266	37640	458 mills. of mills.
Red	 256	39180	477 .....
Intermediate	 246	40720	495 .....
Orange	 240	41610	506 .....
Intermediate	 235	42510	517 .....
Yellow	 227	44000	535 .....
Intermediate	 219	45600	555 .....
Green	 211	47460	577 .....
Intermediate	 203	49320	600 .....
Blue	 196	51110	622 .....
Intermediate	 189	52910	644 .....
Indigo	 185	54070	658 .....
Intermediate	 181	55240	672 .....
Violet	 174	57490	699 .....
Extreme Violet	 167	59750	727 .....

When two equal rays of light, proceeding from two neighbouring points, fall upon a sheet of white paper, they produce a spot which will be twice as bright as either ray would produce singly, provided the difference in the lengths of the two rays is the same. A similar effect takes place if the length is twice, three times, or four times any given distance; but if the rays interfere at intermediate points, that is, if the difference be

equal to one half, or one and a half, two and a half, three and a half that distance, the one light will extinguish the other and produce a dark spot. This is called the *interference* of light, and is analogous to the beats which arise from two musical sounds nearly in unison with each other; the beats taking place when the effect of the two sounds is equal to the sum of their respective intensities, corresponding to the luminous spots where the effect of the two lights is equal to the sum of their separate intensities; and the cessation of sound between the beats, when the two sounds destroy each other, corresponding to the dark spots, where the two lights produce darkness. The colours of grooved surfaces, mother of pearl, &c., may be explained by the doctrine of the interference of light.

If a small sunbeam be transmitted through a perfect prism, and the spectrum be received on a sheet of white paper, it will present the appearance of a ribbon shaded with all the prismatic colours, and striped across its breadth by numerous dark lines: these were discovered simultaneously by Wollaston and Fraünhofer, and are always found in the same parts of the spectrum, and maintain the same relative positions, breadths, and intensities. The light from

the sun, whether direct or indirect, has its own series of lines; and that derived from the planets, and from the combustion of substances, also presents similar lines, but arranged differently in each spectrum. The spectrum from the light of a lamp contains none of the dark fixed lines seen in the solar spectrum. Electrical light, when analysed by the prism, presents very different appearances to the solar light: Fraünhofer found that, instead of the fixed dark lines of the solar spectrum, the spectrum of an electric spark was crossed by numerous bright lines, which (according to Professor Wheatstone) differ in number and position, with the metal from which the spark is taken.

The practical value of Fraünhofer's lines is considerable, as they present a standard of comparison, by which measures can be taken of the refractive and dispersive powers of bodies.

SECTION II.

Anatomy and Physiology.

THE human eye has the form of a sphere having the segment of a smaller sphere attached

to it in front. When it is cut into two parts transversely, each section presents a circular outline, but when the division is made from before backwards, the segment exhibits the form of a larger sphere with a deficiency in front occupied by a portion of a smaller sphere.

The eye is made up of certain tunics or membranes enclosing certain transparent media which are ordinarily termed *humours*, and which perform the office of keeping the membranes expanded and of refracting the rays of light, so that they shall be brought to a focus upon the membrane called the *retina*, which is formed by an expansion of the filaments of the optic nerve.

The anterior transparent part of the eye is termed the *cornea*, and the strong white membrane which forms the remainder of the outer covering of the globe is denominated the *sclerotica*. If we remove these, we shall find a dark brown membrane lining the sclerotic, which is called the *choroid* coat, and to the front of this is attached a coloured flat membrane termed the *iris*, having a circular opening near its centre, known by the name of the *pupil*. If we carefully remove the choroid with its dark pigment, we shall expose an extremely delicate grey, semi-transparent membrane, which is the *retina*.

The interior of the eye is occupied by the humours, of which the *vitreous* is the most bulky, filling nearly four-fifths of the whole globe. Imbedded in the front of this, is a beautifully transparent body of tolerably firm consistence, called the *crystalline lens*, which acts a most important part in the economy of the eye; and in front of this again, we find a clear fluid like water, called the *aqueous humour*, which supports the iris and keeps the cornea plump and expanded. The iris divides that portion of the eye which is between the cornea and the crystalline lens into two parts or chambers (as they are termed), of which the anterior, or that next the front of the eye, is the larger: these chambers communicate through the opening called the pupil.

The substance of the *cornea* is made up of an interwoven mesh of fibres; on its inner surface is an extremely delicate transparent membrane, the "simple homogeneous membrane" of Bowman, which has the property of wrinkling and coiling up in a remarkable manner when removed; and within this again, is expanded the fine membrane which lines the anterior chamber, called the *membrane of the aqueous humour*.

The outer surface of the cornea, as well as the front of the sclerotica, is covered over and pro-

tected by a layer of mucous membrane called the *conjunctiva*—a continuation of the lining membrane of the lids.

The form of the cornea is that of a watch-glass, and it is closely attached at its circumference to the sclerotica: the edges of each are bevelled off, and the cornea is fitted (as it were) within the margin of the sclerotica, the fibres of each interlacing.

The refractive power of the cornea, according to Chossat, is 1.33, which does not differ materially from that of water.

The *aqueous humour* appears to serve at once as a refracting medium, and as a provision for giving form to the anterior portion of the eye; besides which it is beautifully adapted for permitting perfect freedom of motion to the iris. Its refractive power is 1.338. The composition of the aqueous humour, according to Berzelius, is

Water, 98.10.
Albumen, a trace.
Chloride of sodium, 1.15.
Extractive matter, 0.75.

It is supposed to be secreted by the *membrane of the aqueous humour*.

The *crystalline lens*, the most important of the refracting media of the eye, is imbedded in the

front surface of the vitreous humour immediately behind the pupil. In form it is bi-convex; the posterior surface being more convex than the anterior: the anterior surface of the crystalline lens is a portion of an oblate ellipsoid, whereas the posterior surface is a portion of a parabola. It is enclosed in an extremely delicate capsule, between which and the lens is a fluid containing numerous spindle-shaped cells, and similar cells are found upon the surface of the lens. The posterior portion of the capsule is highly vascular, but the vessels cease abruptly near the margin of the lens.

If the anterior surface of the lens be closely examined, three lines will be seen diverging from the centre towards the circumference; and by maceration the lens will separate at these lines into three sector-like parts, each of which is composed of a succession of laminæ upwards of two thousand in number, arranged like the coats of an onion, and reflected from one surface of the lens to the other. These laminæ are made up of fibres, by some said to be flat, by others hexagonal, connected together by a fine dentated edge or rackwork. The external laminæ are loosely connected, but the union becomes gradually firmer towards the centre, the effect being to ren-

der the outer portion of the lens soft, the density increasing towards the centre: thus we trace a beautiful provision in the form and structure of the lens for bringing the rays of light to a perfect focus on the retina, free from both spherical and chromatic aberration; for the rays moving through a medium of such variable density, undergo no sudden or abrupt refractions, but describe a gradual curve, both as they advance into the densest part of the lens, and as they proceed onwards to the vitreous humour.

In infancy the crystalline lens is quite soft, but it gradually becomes of firmer consistence, and in old age is comparatively hard. It is insoluble in boiling water, spirit, and acids; Simon states, with regard to its chemical composition, that in addition to albumen, it contains a substance closely resembling casein, to which he applies the term *crystallin*. Berzelius gives the following as the result of his analysis:

Albuminous matter . . .	35.9
Alcoholic extract with salts . .	2.4
Watery extract with traces of salts .	1.3
Animal matter	2.4
Water	58.0
	100 0

The *vitreous humour* which keeps the retina expanded, and at the same time affords a ready transmission to the rays of light, is composed of a fluid contained in a multitude of cells, made up of the reflection of an extremely delicate and transparent membrane, the *tunica hyaloidea*. It is to this humour that the eye owes its bulk and consistence. Its refractive power, according to Chossat, is 1.339 ; its composition is

Water	98.40
Albumen	0.16
Chloride of sodium with extractive matter	1.42
A substance soluble in water . .	0.02

The form of the eye is maintained by its outer covering, the *sclerotic coat ;* a dense firm membrane composed of white fibrous tissue, and of such a compact texture that it retains its form when emptied of its contents. At its posterior part, and towards the nasal side of the axis of the globe it is pierced by the optic nerve, the outer covering of which is continuous with the sclerotica. It is also perforated posteriorly by the ciliary arteries and nerves. Anteriorly, the sclerotica is wanting, and the deficiency is supplied by the cornea which is firmly joined to it. The front surface (that which is visible as the

"white" of the eye) is covered by an expansion of the tendons of the recti muscles, and over this again is continued the mucous membrane reflected from the eyelids, as already stated.

The sclerotica in many birds presents a series of bony plates imbedded between its two layers, which assist in maintaining the form of the eye. A similar structure is found in reptiles and fishes: in some of the latter, indeed, the sclerotica appears as a bony cup.

The crystalline lens is perfectly spherical in fishes, of great size and extremely dense; a combination of properties rendered necessary from the refractive power of water so nearly approximating to that of the vitreous and aqueous humours.

The eyes of fishes are much flattened, whilst those of birds are elongated from before backwards and are very prominent. Aqueous humour is not needed in fishes, and prominence of the cornea would impede their rapid movements. The aqueous humour is abundant, and the cornea very prominent in birds, to facilitate the rapid adjustment of the eye to objects at different distances.

If we remove the sclerotica, we shall expose the dark *choroid*, which is almost entirely made

up of the ramifications of blood vessels; those on the outer surface being the veins, whilst the arteries are arranged on the inner surface, the larger trunks being most superficial and the capillaries being disposed in an hexagonal form within them. The *choroid* owes its dark colour to a pigment—*pigmentum nigrum*—which is deposited in hexagonal cells on its inner surface. This pigment is most abundant in early life, and diminishes in quantity in old age. It is entirely wanting in "albinos."

The use of the pigmentum nigrum is to absorb the rays of light after they have produced their impressions upon the retina; were it not for this provision, the reflections which would take place in the interior of the eye, would cause great discomfort in broad daylight: such is the case in albinos, who can only see with comfort in the gloom of the evening, they being completely dazzled by the light of day. In certain animals, in place of the pigmentum, we find at the back of the eye a brilliant membrane called *tapetum*, which in the stag is of a brilliant blue, in the sheep of a rich greenish blue, and yellow in the cat.*

* The luminous appearance of the eyes of some animals is not dependent upon a state of excitement, as is commonly supposed

About two lines from the margin of the cornea a dentated line, *ora serrata,* may be observed as terminating the smooth inner surface of the choroid, and the membrane then becomes arranged in a series of plaits or folds, about sixty in number, and of a triangular figure: these are the *ciliary processes,* which are so placed, that the bases of the triangles form a circle around the edge of the vitreous humour, whilst their apices form another circle around the edge of the crystalline lens. They are thickly coated with pigmentum nigrum, which adheres closely to them: the processes taken as a whole constitute the *corpus ciliare,* and the dark depressions left by their removal on the vitreous humour, is known as the *zonula ciliaris.*

The cornea and sclerotica in front, and the iris, choroid and ciliary processes behind, are kept in close connection by a dense white ring, the *ciliary ligament,* which is the medium of connection of all these parts. This is a very im-

but is simply the result of reflection from a bright tapetum. Prevòst shows that it is never visible in complete darkness, that it is the effect of the reflection of light from without, and that it can only be seen in certain positions. It has been observed by Tiedemann, after the head had been separated from the body full twenty hours. The yellow tapetum of the cat is especially favourable for the development of this luminous appearance.

portant structure; for through it, inflammation commencing in the iris, cornea, sclerotica, or choroid, is readily propagated from one to the other.

The arteries which ramify on the inner surface of the choroid (short ciliary) are twenty or thirty in number, and are derived from the ophthalmic. They enter the eye by piercing the sclerotica near the optic nerve, and it is to this circumstance, and their being so completely concealed by that dense membrane, that so little redness accompanies inflammation of the choroid coat.

The veins of the membranes are called *vasa vorticosa*. They ramify on its external surface, and collect into four trunks, which pass out through the sclerotica, about midway between the cornea and optic nerve.

The iris is a flat and coloured membrane, in form like a quoit, attached by its external margin to the ciliary ligament. It is one of the most important parts of the organ. It divides the cavity which contains the aqueous humour into two compartments, that in front of the iris being termed the anterior chamber, that behind it the posterior chamber. The circular opening in the middle of the iris, and a little toward the nasal side, is called *the pupil*, through which light is admitted into the interior of the globe. The term "iris," strictly speaking, is applied to the

front surface of the membrane, the colours of which vary materially in different individuals, and even in the same eye:—A grey or blue eye, for instance, may have a yellow pupillary margin, or there may be streaks of different colours extending from the pupil to the outer margin. A distinguished writer,* when speaking of the iris, says, "In respect to these varieties there is a marked difference between the human species and animals.

"It may be said of all animals, in their natural or wild state, that the colour of the iris is constant in the same species.

"Domesticated animals, with greater diversities in the general colour of the body, have, in some degree, a corresponding diversity in that of the iris: but in no instances are there such numerous differences as in the human subject. The colour of the iris generally corresponds to that of the external surface; it varies according to the complexion of the individual, and the colour of the hair. In those of fair complexion and light hair, the iris is either blue or grey, or of some light tint: such persons are said, in common language, to have light eyes. In persons of dark complexion and hair the iris has a deeper

* W. Lawrence. A Treatise on the Diseases of the Eye, p. 22.

tint—dark grey, brown in various shades, of which the deepest is called black. In the human subject the iris is never, strictly speaking, black; the eyes which we call black, are of a dark brown, and they always accompany dark hair, and more or less swarthy complexions."

"The individuals of the German race are distinguished by the lightness of their hair, the fairness and ruddiness of their complexion, and by blue or light grey eyes."

"This combination of physical characters is remarked by Tacitus, in his treatise De Moribus Germanorum (rutilæ comæ, cærulei oculi): where rutilæ probably means the colour which we call flaxen: this sort of hair and light blue eyes, are circumstances which characterise the German race at this day, as strongly as at the time when Tacitus described them. All the dark complexioned races, the Sclavonians, the Celts, the Orientals, (as the Turks and the inhabitants of the western part of Asia,) and the dark-coloured races properly so called, have dark hair and the darkest irides."

"In the negro this characteristic is most striking, for the iris is so extremely dark, that you are obliged to look closely to distinguish between it and the pupil. In the eye, as well as in the hair and in the skin, the colouring substance

seems to be something adventitious, which does not belong to the basis or natural texture of the part. So it is in all substances, for when it is removed, the fundamental structure remains."

"This is the case with respect to the individuals called Albinos, who are distinguished by a peculiar and almost morbid kind of whiteness: whose hair has a white, almost satiny appearance, and whose skin is of a dead, sickly white. In these individuals, the colouring substance of the choroid coat, and of the iris, is deficient; and the pupil, instead of being black, is of a rose or pink colour: the iris has the same pink tint in a greater or less degree, but its colour is never so deep as that of the pupil. The choroid pigment, and that of the uvea, are entirely wanting; but the iris often possesses a little colour, light blue or grey; its texture is, at the same time, so thin, from the absence of the uvea, that the red of the choroid is partially seen through it. The colour of the iris and pupil in these cases depends on the multitude of blood vessels entering into the texture of the former and the choroid. If we examine the eyes of such individuals, after the vessels have been injected, the choroid coat presents the appearance of an uniform red membrane without any colouring

substance. In the ferret, and in the white rabbit, there is the same deficiency of colouring substance, and the red colour of their eyes is well known."

The functions of the iris are of great importance, and the first and most obvious is that of regulating the quantity of light admitted into the eye. When the light is too strong to be agreeable to the eye, the pupil is contracted. On the other hand, when the light entering the eye is not sufficient, the pupil is dilated. So that in all cases the iris admits, by adjusting the pupil, just that amount of light which enables the retina to perform its functions perfectly. Opticians make use of a screen, or diaphragm, in telescopes and microscopes, to exclude the light from the circumference of the object glasses, and thus by admitting the central rays only, secure a clear and well-defined image. This it effects by lessening that spherical and chromatic aberration due to the circumferential rays. The iris presents a specimen of such a diaphragm in its most perfect form ; being opaque, it arrests those rays which enter the eye too obliquely, and which, were they to pass through the crystalline lens near its margin, would interfere with the perfection of the image, by casting a halo around

it. It thus, by its regulated contraction, and by preventing spherical and chromatic aberration, secures a distinct and sufficiently vivid picture upon the retina. When we look in the distance the pupil expands to admit an increased quantity of light, without which objects would appear obscure;—when we look at near objects it contracts to exclude the circumferential rays which would render the picture upon the retina indistinct.

During sleep the pupil is greatly contracted, and the eye turned upwards and inwards. This may be presumed to be that state or position in which the muscles of the eye are at rest.

The front surface of the iris presents, upon close examination, numerous fibres radiating towards the margin of the pupil, near which they collect into clusters, and again separate, but are closely arranged immediately around the pupil. This portion,—that is, the inner portion of the iris, is composed of circular fibres. It is by means of the antagonism of these two sets of fibres, that the size of the pupil is made to vary; for, by the contraction of the circular layer the pupil is diminished, whilst it is expanded by the contraction of the radiating fibres. The dilatation caused by belladonna appears to be due

in part to its paralysing effect upon the circular fibres, and to its stimulating effect upon the radiating fibres, causing the latter to act with energy sufficient to keep the pupil widely dilated.

The posterior surface of the iris, called the uvea, is of a deep brown hue, and is covered by a considerable quantity of black pigment, deposited in a sort of cellular tissue; it is separated from the aqueous humour by the delicate membrane which lines the posterior chamber, and which is spread over the back of the iris. The use of this dark pigment is, doubtless, to render the iris impervious to light, and to prevent the reflection of luminous rays from it into the interior of the eye.

The iris is freely supplied with blood, and the arrangement of the vessels is peculiar. There are two long ciliary arteries, which are branches of the ophthalmic artery: they pierce the sclerotic near the optic nerve, and run, one on each side of the globe of the eye, between the sclerotic and choroid until they approach the iris; each then divides at an acute angle into two branches, one directed upwards, and the other downwards; the upper branches communicate, and so do the lower, surrounding the iris with a circle of vessels increased by the inosculations of the

anterior ciliary arteries, and from this a multitude of branches radiate in the substance of the iris towards the pupil, around the margin of which they unite to form another circle; from this, small branches are given off which form a third circle by their anastomosis immediately upon the margin of the pupil. This arrangement is peculiar to the human eye, and it has been suggested by my friend Mr. John Quekett, who has especially described it, that the outer circle performs the office of a coarse adjustment; the inner, that of a fine adjustment.

The red zone seen around the margin of the iris in iritis, is the result of the congestion of the external circle of vessels.

The nerves which supply the iris are derived from the lenticular ganglion.

The circular form of the pupil in man enables the eye to see equally in every direction; in sheep, and such animals as seek their food with their heads bent down towards the earth, the pupil is oblong in a horizontal direction, so that the eye receives the rays from objects immediately before it, and on each side. In the cat tribe the pupil is perpendicular, a form especially well adapted for seeing upwards and downwards, as their climbing habits renders desirable. During the

night the pupils of these nocturnal animals, by assuming a circular form, become exceedingly large, and thus take in as many rays as possible, whilst during the day they are contracted to a mere chink, but as this chink is perpendicular, the animal can pursue its prey with facility, even during the day.

The iris in birds is remarkable for its activity, and for the extent of its movements. In many birds these movements appear to be voluntary. This is conspicuous in the parrot tribe, but it has been observed in the cassowary, and others.

In fishes, the pupil is usually very large, but motionless.

Of the rays which impinge upon the cornea, a portion is reflected, but the remainder passing through the cornea undergo considerable refraction. The cornea and the capsule of the crystalline lens, may be considered as forming the anterior and posterior surfaces of a meniscus, of which the fluid called the aqueous humour forms the refracting medium. The circumferential rays which if continued would interfere with the perfection of the image upon the retina, are reflected or absorbed by the iris: the remainder pass through the crystalline lens, and undergo considerable further refraction, which is increased

by the vitreous humour until the rays are brought to a focus exactly upon the retina, where they present an inverted image of the object.

All reflections from the surface of the retina into the interior of the eye are prevented by the absorption of the rays by the black pigment lining the choroid, and the inner surface of the uvea.

The optic nerve enters the globe by a foramen in the sclerotic and choroid coats; and it is considerably diminished in size at the point of perforation. It then forms a small prominence called "*papilla conica*," from whence the nervous filaments diverge to form the retina. In the dead eye the retina appears a blueish white semi-transparent membrane, of the utmost delicacy. In the living eye the retina is transparent and is kept in a state of expansion by the vitreous humour; it lines the choroid as far as the commencement of the ciliary processes, where it terminates by a scalloped border.

The *retina* may be most conveniently described as consisting of three layers: the *outer* layer, or layer furthest from the centre of the eye, usually regarded as a distinct membrane under the name of *membrana Jacobi*, is made up of an aggregation of rounded or prismatic columns, about

$\frac{1}{1000}$ of an inch in length and $\frac{1}{6000}$ of an inch in thickness. These are arranged like mosaic work upon the external or convex surface of the expanded fibrillæ of the optic nerve, of which the *middle* layer of the retina is composed.

The fibres of the optic nerve immediately after passing through the sclerotic separate into tufts, and pass forward in fasciculi, which form plexiform groups between which spaces exist. The fibres are exceedingly delicate, their diameter varying from $\frac{1}{6000}$ to $\frac{1}{8000}$ of an inch; they pass forward, and having proceeded a certain distance, each fibre bends towards the vitreous humour, passing, as it does so, through the third or *inner* layer, which is made up of a net-work formed by the ramifications of the central artery and vein of the retina; from this, each fasciculus of fibres receives an investment: the fasciculi then terminate in papillæ so organized and so arranged on the outer surface of the vitreous humour as to be susceptible to the influence of the rays of light, and there is reason to believe that it is to the vibrations excited in them by the undulations of the rays, that we are rendered conscious of the phenomena of light and colours.

The retina in the living subject is perfectly transparent, but it speedily becomes opake after

death. In the cuttle fish, the inner surface of the retina is covered by a layer of dark pigment, and it was for some time a matter of discussion how it could receive the impressions of light; but it is now proved that the pigment is penetrated by the papillæ of the retina.

The optic nerve does not enter the eye exactly at its axis, but about one-fifth of an inch nearer to the nasal side. In the axis, a pale yellow spot, *foramen of Soemmering*, is observed: it is about a line in diameter, and Krause describes it as being formed by a gap amongst the fibrillæ of the retina which appear piled up around it; that it is not a foramen is certain, because it is covered by the vascular layer, and also by that structure described as the *membrana Jacobi*.

The impressions made upon the retina do not immediately pass away, but continue for a longer or shorter period according to their intensity. If, for example, we look at the sun, or the combustion of lime in oxygen gas, the spectrum will remain for a considerable period, (probably longer in old age than in youth,) appearing black if we look upon a white surface, or white if the eyes are closed. It is by this persistence of the image that we do not lose sight of our object during the act of wiping the eyes, called winking.

In like manner when we whirl with rapidity a burning stick, we perceive a complete circle of light, although the burning extremity can only be in one part of the circle at the same instant. The retina is endowed with the power of conveying impressions of light only, and any irritation of it gives rise to the sensation of light: thus a blow upon the eye excites the appearance of a flash of fire; pressure upon it causes a luminous circle, and a characteristic symptom of inflammation of the retina is the appearance of sparks, or flashes, or globes of fire. These flashes are not real, and of course unattended with any emission of light, consequently are never visible to any other person than the subject liable to perceive them in his own eyes. This is important in a medico-legal point of view, for Müller alludes to a case in which a person was said to have recognized a robber by the light produced by a blow on the eye.

Dr. Abercrombie mentions a curious instance of the effect produced by the persistence of the image upon the retina.

A gentleman had been looking intently at a print of the virgin and child, and had sat down bending over it for some time; on raising his head, he was startled by perceiving at the farther

end of the room, a female figure of the size of life, with a child in her arms. The illusion continued for about two minutes, and then passed away. Cases have occurred where the illusion last much longer.

The eye derives its sensibility from the fifth pair of nerves, the ophthalmic branch of which sends filaments to the conjunctiva, whilst the long root of the ciliary ganglion from the nasal branch of the fifth supplies the interior of the eye with sensibility: the motor power of the iris is derived from the branch of the third pair which goes to the ciliary ganglion, and the nutrition of the eye appears to be governed by the filaments from the sympathetic.

If, before a hole made in the window-shutter of a darkened room, a double convex lens be placed, an inverted picture of the scene without, will be pourtrayed by the lens upon a piece of white paper.

In like manner an inverted picture of external objects is formed upon the retina by the passage of the rays through the eye. This fact may be made manifest, for if after exposing the retina of the eye of a sheep by carefully removing the posterior portions of the sclerotic and choroid, the pupil of such eye be directed towards the flame

of a candle, an inverted image of that flame will appear upon the retina.

The circumstance of the image being inverted has proved a most fertile source of discussion as to why objects are not seen upside down; many elaborate explanations have been offered to account for it. That proposed by Dr. Whewell is the following, and may be deemed satisfactory.

"The first paradox of vision,"* says he, "is, that we see objects upright, though the images on the retina are *inverted*. The solution is that *we do not see the image on the retina at all, we only see by means of it*."

"A difficulty has been raised arising from the neglect of this most obvious distinction. It has been asked, how is it that we see an object upright when in fact the image on the retina is inverted?"

"To this we reply, that we have no notion of upright or inverted except that which is founded on experience. A man is upright when his head is upwards and feet downwards. Whatever be our standard of up or down, the sensible representation of *up* will always be an image moving

* Philosophy of the Inductive Sciences, Aphorism lxv. p. xxviii.

on the retina towards the lower side, and the sensible representation of *down* will be a motion towards the upper side. The head of the man's image is towards the image of the sky; its feet are turned towards the image of the ground; how then should it appear otherwise than upright?

"But, perhaps, we expect that the whole world should appear inverted; but if the whole world be inverted, how is the relation of parts altered? (for we regard all objects in relation one to the other)—we do not see the image on the retina, *but by means of it.*"

For *single vision* it is essential that our eyes be so adjusted, that the image formed in each, shall fall on corresponding points of the retina; unless this condition exists, we find that double vision occurs. It is those parts alone of the retina which correspond in situation, that are identical in sensation.

The experiments of Professor Wheatstone have satisfactorily demonstrated that we derive our idea of the *solidity* of an object—that of a cube for example—from two dissimilar perspective projections of it being presented simultaneously to the sensorium by the two eyes. This is proved by an ingenious apparatus—the *stereo-*

scope, invented by the Professor. A person who has lost one eye supplies the defect by the motion of his head, by which means he causes his single eye to receive different pictures of an object, such as would otherwise have been received by the two eyes. A full explanation of the subject will be found in the Paper by Professor Wheatstone, Philosophical Transactions for 1838, p. 371.

CHAPTER II.

MYOPIA OR NEAR SIGHT.

EVERY eye, when in a state of rest, is adapted by its figure and size, and the refractive powers of its media, to the formation of a distinct picture of an object presented before it at one particular distance.

The distance at which ordinary print is legible varies from twelve to twenty inches.* The shortest distance at which it can be seen with distinctness and without exertion, is from six to eight inches. Any one who habitually brings small objects nearer to the eyes than this may be considered short-sighted. The term *myopia* (μυω, I shut, ὤψ, the eye), has been applied to this condition, because short-sighted persons,

* Dr. Young states that Mr. Abernethey had perfect vision from three inches to thirty, and that Dr. Wollaston could see well at seven inches with converging rays.—On the Mechanism of the Eye. Phil. Trans. 1801.

when looking at distant objects, are in the habit of half closing the lids.

Myopia may be treated of under two heads.

I. When it arises from imperfection in the form, consistence, or relation, of some of the refractive media.

II. When it arises from the loss of adjusting power.

I. *Myopia from imperfection in the form, consistence, or relation, of some of the refractive media.*

The most frequent cause of myopia is too great a convexity either of the cornea, or of the crystalline lens, or of both. In many cases of aggravated myopia I have satisfied myself that the cornea had too much curvature, and that the anterior chamber was preternaturally large.

Fig. 3.

Myopia, however, may be the result of too convex a crystalline lens,* or of too great distance between the cornea and retina, arising from the mass of vitreous humour being greater than the other parts of the eye require.

An undue density of any or of all the refractive media, though the figure of the eye be normal, may also occasion this affection.

Instead of the rays of light from objects at the usual distance being concentrated to a focus on the retina, which is essential to distinct vision, they are, by being so much refracted,† brought to a focus before they reach the retina, as shown in the adjoining section.

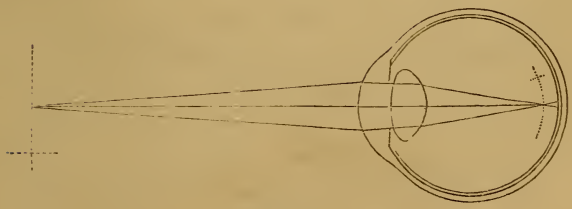

Fig. 4.

* Jesu Haly mentions as one of the causes of myopia *enlargement* of the crystalline lens. (De Oculis, iii. 6.) Alsaharavius states that exposure to cold and snow, sometimes occasions nearsightedness. Paulus Ægineta sets down myopia as wholly incurable, "being occasioned by a weakness of the optic spirit."

† The sine of the angle of refraction is a constant quantity,

Short-sighted persons, in holding objects near the eye to procure distinct vision, are acting in conformity with the laws of optics, for the nearer an object is brought to the eye, the more divergent are the rays which proceed from it, and the further they will have to go before the refractive power of the eye will be able to bring them to a focus. So that whilst the picture of an object which is ten inches off would be formed, as in Fig. 4, before the retina, and of course be indistinct; one placed at four inches from the eye might have its picture formed distinctly on the retina, as shown in Fig. 5.

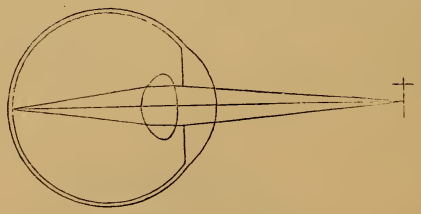

Fig. 5.

The discovery of short-sightedness is generally made by accident, either by comparing the sight

and, therefore, although the size of the angle is less when the impinging ray is near the centre of the cornea, it is only as much less as the ratio which it bears to the sine of the angle of incidence requires it.

with that of others, or by looking through a concave lens. A patient told me the pleasure he experienced on looking through a glass for the first time, was as great as if he had acquired a new sense. Although fond of theatrical amusements, he had never clearly discerned the features of the performers on the stage, and had frequently experienced surprise at the remarks made by others whose sight he considered to be extraordinarily acute. A concave glass of low power enabled him to see the features of persons at a distance, which he had never before conceived possible.

A young woman complained that when looking at small work at a moderate distance from the eye, a sensation of aching came on. By way of amusement, she was invited to put on a pair of spectacles of ten inch focus, when she exclaimed to the astonishment of all present, "How plain everything is! I can see what o'clock it is more distinctly than I ever could before." The time-piece being at least three yards off, and the dial small.

Near-sighted persons see with less effort in partial darkness than those whose sight is perfect, for to the former it is natural to bring the object close to the eye, and they receive the full

advantage of all the light which proceeds from it,* whereas persons who are not short-sighted are obliged under similar circumstances partially to close the eyes and contract the pupils in order to see distinctly; consequently much less light enters their eyes than those of the myopic individual, and they therefore see with less distinctness and more effort.

Distant objects appear large to near-sighted persons, because a distinct picture is formed only at the point of intersection of the rays proceeding from an object, and as this point falls short of the retina in these persons, the retina receives the rays beyond the point of intersection, and consequently where they are more extended.

Near-sighted individuals often write a very small hand: the proximity of the letters to the eyes increasing the visual angle subtended by them, and causing them to appear distinct enough.

If a near-sighted person looks through a pinhole in a card, he can distinguish objects clearly at a greater distance than before; this is effected by excluding the circumferential rays, which by

* In connection with this circumstance it must be borne in mind that the quantity of rays from an object is always in an inverse ratio to the square of the distance.

their too speedy convergence would tend to form foci *before* they reach the retina, and thus cause indistinctness of vision. The pupils of the eyes of myopic persons are generally large, and their habit of half closing the lids when looking at distant objects is upon the same principle, that is, for the purpose of excluding all but the central and direct rays.

The space upon the retina acted upon by rays of light passing through an aperture, depends upon the size of the aperture, and its distance from the eye. Diminish the aperture or increase its distance from the eye, and such space may be reduced indefinitely. When, therefore, indistinct vision arises from any of the surfaces either of the cornea, or of the crystalline lens, or of the retina not being adapted in form to each other, or to the refractive media contained by them, we have the following as reasons for distinct vision through small apertures.

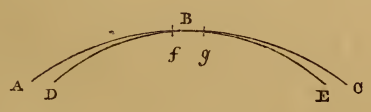

Fig. 6.

Let the curve A B C, Fig. 6, be a section of an existing surface, whether of the retina, or cornea, or crystalline lens, producing, or aiding in the production of indistinct vision; and let D B E be a curve supposed to be capable of producing distinct vision, and placed for the sake of illustration touching the curve A B C, at the point B; then, so long as the respective portions of the surfaces acted upon by the light passing through the aperture are contained within a short distance of B—as, for instance, between *f* and *g*: not only do the true curve and the untrue one so nearly correspond in form as scarcely to admit of a perceptible difference; but those circumferential rays that would have fallen upon the untrue surface, and have produced confusion by their crossing, are prevented entering the eye by the opake substance in which the aperture is made. And although, for the sake of illustration, it was supposed that the curve adapted for distinct vision coincided at the point B, with the curve of indistinct vision, yet, as the rays of light that flow from any one point on an object seen through the aperture, form an exceedingly minute angle with each other, indistinct vision could scarcely be produced, whether the surface of the retina were a little nearer to the front of ness, and some alteration in the colour of the

the eye, or a little more remote from it, than a surface correctly placed would be.

Nearsightedness is one of the symptoms accompanying Hydrophthalmia or *Dropsy of the anterior chamber*, which is caused by excessive secretion of the aqueous humours, the result of inflammation of the secreting membrane. It is of importance not to confound this with simple myopia, as the two affections ought not to be treated alike. When we deal with myopia, the result of inflammation, we adopt measures to arrest the secretion by removing the inflammatory action.

Strumous children are most liable to this disease, and the exciting cause is either inflammation of the cornea and aqueous membrane together, or of the aqueous membrane alone (*aquæ capsulitis*). If the former, the myopia will have been preceded by more or less redness of the cornea and the appearance of a zone of vessels around it; pinkness of the sclerotic, intolerance of light, and some opacity of the cornea. If, however, the inflammation has been confined to the aqueous membrane, the cornea will not have been affected externally, but upon close examination will appear slightly turbid, with whitish spots visible upon its posterior surface, giving to it a mottled appearance. There will also be dul-

iris, and not uncommonly some intolerance of light and vascularity of the sclerotica; and though there will not be much pain, there will be a sense of weight, and of distention of the globe.

If such a case presents itself to us after the acute symptoms have subsided, the first thing that will strike us will be the enormous size of the anterior chamber: twice or three times as large as usual. The flat surface of the iris appears to have receded from its natural position, the unusual amount of refractive power of the excessively protuberant cornea, giving it the appearance of being concave. In some cases there does not appear to be much alteration in the form of the cornea; it appears thinner, but does not assume the pointed form characteristic of conical cornea. The extra prominence is general.

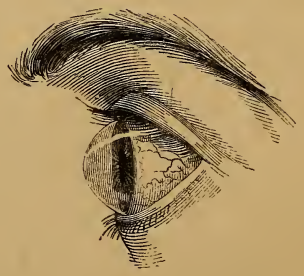

Fig. 7.

In the cases which have fallen under my observation, there has always been more disturbance of vision than the altered form of the cornea could account for. The movements of the iris have been impaired, and in some instances it has been quite insensible to the stimulus of light. In other cases the iris has been tremulous. In all, there has been a tendency to amaurosis, and although in some favourable cases of dropsy of the aqueous chambers, the retina is sound; in the majority, its sensibility, so far as my experience goes, is somewhat impaired.

Conical cornea in its early stage may be confounded with simple myopia, as it gives rise to nearness of sight. The disease consists in an elevation of the central portion of the cornea into a pyramid or cone, giving to the eye, from the peculiar form of the reflecting surface, an unusual amount of brilliancy. Conical cornea is most frequent in the female sex, and usually occurs about the period of puberty. It would appear to be the result of absorption of the cornea near the centre, and its consequent yielding to undue pressure from behind. In a case which Dr. Jäger of Erlangen had the opportunity of examining after death, the apex of the cone was found to be very thin, and Mr. Ward-

rop mentions the case of a gentleman afflicted with this disease, whose cornea was burst by a blow upon the eye from a whip.

Conical cornea commences without any apparent cause; its progress is painless and slow, and it generally affects one eye more than the other. An early symptom is shortness of sight, and as the disease advances, vision becomes most seriously interfered with; the only sight indeed the patient then has, is through the side of the cornea, so that objects are not only held extremely close to the eye, but on one side of it. Objects also appear multiplied from irregular refraction of the incident rays produced by inequalities on the surface of the cornea.

The disease may be best recognised laterally, when the conical cornea will be seen having much the appearance of a piece of pure crystal attached to the front of the eye.

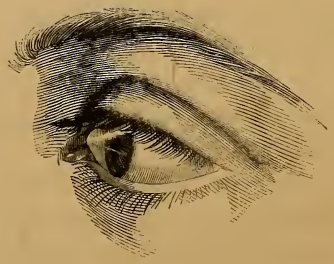

Fig. 8.

When the disease is far advanced, the apex of the cornea is liable to be rendered opake by the irritation caused by the friction of the lids.

I have known an instance of imperfect *congenital cataract* that was for many years mistaken for aggravated myopia.

Case I.—"The patient, a gentleman of thirty years of age, in consulting me respecting his sight, states, that he has been exceedingly near-sighted from childhood, and acting under the advice of a medical man, he has for some time worn double concave glasses, but without deriving benefit—that his sight is decidedly getting worse. Upon his attempting to read tolerably large type, he holds the book very near to his eyes and turns his back to the window, that at the same time he may illuminate the object and keep his eyes in the shade. It is with difficulty he makes out even a few words, saying that the letters appear confused and misty. On examining the pupils when under the influence of light, I find them contracted to the size of mere pin-holes; small however as the pupil is, beyond it I perceive something grey. To ascertain the nature of this, I put the eyes under the influence of atropine, and then have a distinct view of a cataract, greyish and jelly-like, obstructing the

central portion of each pupil, but allowing while the pupils are dilated, of the access of light all around. Through this space, my patient for the first time in his life sees distinctly. All objects appear to him to have undergone a transformation as if they had been touched with a magician's wand. Upon looking at a mirror, he discovers for the first time that his eyes are blue. Colours appear immeasurably brighter than he had ever imagined, and though the day is cloudy, he expressed much surprise at the brightness of the light. The glory of the sun he has yet to see. This morning he first discerns the features of the members of his family, and it is highly interesting, and not a little touching, to observe his feelings, and the surprise he evinces at the erroneous impressions which he had formed, for as he observes, 'Until now I have never seen like other people.' It is a satisfaction to me to be able to state, that by a very trifling operation his newly-acquired powers of vision have been rendered permanent."

A myopic condition of the eyes may be suddenly induced, as in the following cases related by Dr. Smith.*

* A complete system of Opticks, by Robert Smith, L.L.D., vol. ii. p. 61.

CASE II.—" Dr. Briggs mentions a person above seventy years old, who has used spectacles for ten years, and yet by catching cold by reading in the winter-time too near a window, he suddenly became so short-sighted, that he could not distinguish objects three feet off, and after his cold and defluxion was cured, he continued to read the smallest prints without spectacles for many years."

CASE III.—" I know a young gentleman who became short-sighted immediately after coming out of a cold-bath in which he did not totally immerse himself, and ever since he has used a concave glass for many years."

Myopia may be caused by abdominal irritation as in the following case:

CASE IV.—" *Myopia, caused by intestinal worms.*—On the 25th of January 1845, I saw a young gentleman aged thirteen, who was stated to have suddenly become near-sighted. Three weeks previously, it was observed that he seemed to read with difficulty, and to hold the book very close to his eyes; he was also unable to discover distant objects. Prior to that period his vision had been good, but he was pallid, of a feeble constitution, and had occasionally been troubled with worms from infancy.

"Upon examination of the eyes the pupils appeared rather dilated, but acted freely under the stimulus of light, and no abnormal appearance was to be detected. When he attempted to read, he held the book at about five inches from his eyes, and in an oblique position; he could not discern features at a distance of fifteen feet. Both eyes seemed equally affected, but he could read more easily by looking through a pin-hole in a card. Upon applying a double concave glass of thirty-six inches focus to his eyes, his vision was improved, and on looking through one of thirty inches focus, he said he could see "nearly as well as ever." Upon inquiry I was informed, that his breath was fœtid, his appetite capricious, and that he ground his teeth when asleep. Believing that the affection of the vision was in connexion with abdominal irritation, I prescribed three powders, each containing three grains of calomel, four of scammony, and four of jalap: one to be taken every night, and the evacuations to be watched. No worms appeared on the first morning, but on the second, a large *ascaris lumbricoides* was passed; and after the third dose, two more came away. I then prescribed ten drops of the tinct. ferri sesquichloridi in an ounce of inf. quassiæ, thrice a day,

and another purgative powder at the expiration of three days, but no more worms were expelled. At the end of a week I had the satisfaction of finding that an improvement had taken place in the vision; at the expiration of a fortnight he left town, but I subsequently heard, that by steadily pursuing a plan of diet and medicine which was laid down, together with exercise in the open air, his sight continued to get better, and in two months was quite restored."

TREATMENT.—It has been explained that true myopia arises from the want of adaptation existing between the refractive powers of the eye, and the situation or the form of the retina. The resources of art have been made successfully to supply such want. When treating of spectacles, I shall name the chief points to be attended to in their selection, and shall here confine my observations to the manner in which they act, and the mode in which they are to be used.

Concave glasses are required by near-sighted persons, and double concaves are better than single concaves. They both render parallel rays divergent, and divergent rays still more divergent; thus causing the picture of an object to be thrown back upon the retina instead of being

anterior to it, as is the case in the unassisted myopic eye.

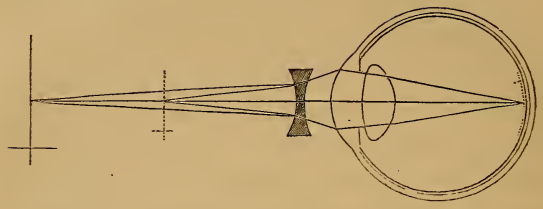

Fig. 9.

It is not only of the highest consequence that near-sighted persons should avoid increasing the power of their spectacles needlessly, but they should carefully avoid wearing them constantly; for with proper care of the eyes, such as the avoidance of much close application, of reading by the light of a hot fire, or studying by too brilliant a light, glasses of a low power will answer every useful purpose for a long series of years.

Dr. Kitchener has written so sensibly, and withal so feelingly, upon the evil consequences resulting from a too frequent change of glasses, that I shall quote his words.*

"Being a short-sighted mortal myself," says he,

* The Economy of the Eyes. By W. Kitchener, M. D. p. 95.

"I write this chapter with confidence, from my own experience of upwards of thirty-one years, and hope to be able to give some good advice to those who are unfortunately what is called near-sighted. I was about fifteen years old when I first discovered that I could not discern distant objects so distinctly as people who have common eyes usually do; and seeing I could not see what persons with common eyes frequently pointed out to me as well deserving my attention, I paid a visit to an optician, and purchased a concave eye-glass, No. 2.

"After using this for some time, I accidentally looked through a concave, No. 3, and finding my sight much sharper with this than with No. 2, had my spectacles glassed with No. 3, which appeared to afford my eye as much assistance as it could receive.

"After using No. 3 for a few months, I chanced to look through No. 4, and again found the same increase of sharpness, &c., which I perceived before when I had been using No. 2 and first saw through No. 3; therefore concluded that I had not yet got glasses sufficiently concave, and accordingly procured No. 4. However, this soon became no more stimulus to the optic nerve than its predecessors Nos. 2 and 3 had been.

" I then began to think that the sight is subject to the same laws which govern the other parts of our system: i. e. an increased stimulus by repetition soon loses its power to produce an increased effect; therefore I refused my eye any further assistance than it received from spectacles glassed with No. 2, which I have worn for upwards of thirty-one years, and it is very nearly, if not quite, as sufficient help to me now, as it was when I first employed it, giving me a sight (for objects at a moderate distance,) as I find by comparison, about upon a par with common eyes."

Dr. Wells,* in his experiments and observations, states that he was informed by Mr. George Adams, an eminent optician, " that he does not know a short-sighted person who has had occasion to increase the depth of his glasses if he began to use them in the form of spectacles; whereas he can recollect several instances where those have been obliged to change their concave glasses repeatedly for those of higher powers who had been accustomed to apply them to one eye only."

The above is a fact which ought to be

* Experiments and Observations on several subjects in Optics. London, 1818.

more generally known, and is an argument against the use of single eye-glasses. Near-sighted persons are very apt to stoop while at their studies. To avoid a practice so injurious to the figure and to health, a high desk should be provided to read and write at, and such glasses should be used as are just sufficient to enable the parties to pursue their occupation at the ordinary reading distance, that of about fourteen inches.

In all cases of myopia, and especially in early life, or when the affection is just commencing, it is highly important that any tendency to an over-supply to the eyes should be counteracted by a proper quantity of bodily exercise. The adjusting power of the eyes should also be daily exercised in the attempt to obtain a distinct view of objects at a distance. Long-continued exertion of the eyes in reading, writing, needlework, and similar pursuits, tends to aggravate the disorder, and should be carefully avoided.

Mr. Guthrie has suggested the application of leeches to the eyelids at regular and pretty frequent intervals, where myopia appears about the period of puberty, supposing that the defect arises from the too rapid development of certain parts of the eye. Mr. Middlemore states that he

has tried this plan, and that it has most unequivocally failed.*

As the myopia which comes on at that period may frequently be traced to a partial loss of the power of adjustment to distant objects, no great advantage would in such cases be likely to accrue from local depletion.

M. Bonnet, of Lyons, was of opinion that one form of near sight arises from the muscles of the eyeball acting so energetically on it as to elongate its anterior axis, thus rendering the cornea unnaturally prominent: and he attempted to remove some of the pressure by dividing the inferior oblique muscle. In nine cases, he states, in which this operation was performed, the distance of distinct vision for reading was nearly doubled, and that for distant objects trebled, or even quadrupled.

M. Guerin, in a communication to the Academy of Sciences, describes two species of myopia, the *mechanical* and the *optical*. The mechanical he considers to result either from the original shortness, or the undue contraction of the four recti muscles together, or of two or three only. In such cases M. Guerin recommends

* A Treatise on the Diseases of the Eye. Vol. ii. p. 207.

the subconjunctival division of the short or contracted muscles. He relates a case of a young woman in whom he states that he divided all the four recti muscles with great alleviation of the symptoms !

It may be a question, however, whether either of these remedies is not worse than the disease, more especially as relief can always be afforded by glasses.

Myopia dependant upon loss of power of adjustment to distance.

That a power of adjusting the focus of the eye to different distances exists in the healthy eye is proved as follows :

Let a person place a couple of thin objects fifteen or twenty yards asunder, in a line with one eye, (the other being shut,) and let the nearest object be a yard from the eye. On fixing the eye upon the nearer object, he will perceive the distant one to be indistinct, and on looking at the distant object, the nearer one will become indistinct, and at each change of the object of vision he will be conscious of an alteration in the adjustment of the interior of the eye.

If, then, a person employs himself for long

periods together, and that for successive days, in reading, microscopical observations, or other pursuits requiring close application, he becomes, not strictly near-sighted in the usual acceptation of the term, for he does not hold objects much nearer to the eye than usual, but he finds that he discerns distant objects less and less distinctly. In fact, he finds that the eyes being exercised so much in adjusting the focus for near objects, lose the power of adjustment to the focus for distant objects. I have been much struck with the prevalence of concave spectacles amongst the Germans who are great readers, and many must have noticed the same prevalence at our Universities. Mr. Ware found, that out of 127 students at one college in Oxford, thirty-two used either a hand-glass or spectacles. Indeed, I believe that few persons of studious and sedentary habits entirely escape this consequence of their labours: it is the price they pay for their neglect of the perfect action of the eye.

Case V.—A gentleman, aged 19, consulted me, December 3rd, 1845. He stated that for three months he had been almost incessantly engaged in drawing plans, sections, &c., of railroads; that his sight, which had been excellent up to that period, had in consequence been so

much impaired, that although he was still able to write and draw at the ordinary distance, he could not distinguish the features of persons on the opposite side of a street, and he was much troubled with muscæ volitantes in his left eye. He had ascertained that with the assistance of glasses he could see perfectly well, and his object in calling upon me was for advice as to the description of spectacles that would be proper. My advice to him was on no account to use glasses, but to go into the country and give his eyes perfect rest by abstaining in toto from the pursuits upon which he had been recently engaged. An alterative course of medicine was prescribed, and he was directed to apply a blister over the left brow, and to repeat it three times, with an interval of a week between each application.

My patient called again at the expiration of a month, and stated that his general health was much improved, that the muscæ had nearly disappeared, and that there was a decided amendment in his vision. He was recommended to pass another month in the country, and to exercise his eyes freely upon distant objects. By the last accounts he was still in the country, had been taking much exercise, and stated that his sight was nearly restored.

Case VI.—A gentleman, aged 20, consulted me in January, 1845. He stated that he had enjoyed excellent vision until seventeen years of age, at which time he began to read daily for ten hours, allowing himself only an hour's exercise. He paid little attention to the fact, that at the end of three months of this close reading his vision for distant objects was less perfect, but went on with his studies, till at the end of six months he found that he could not distinguish a person's features at the distance of thirty feet. He then provided himself with glasses which assisted his vision, but still his sight became worse, and he accordingly used stronger and stronger glasses. When I saw him he was using a lens of 11 inch focus for his right eye, and one of 7 inch focus for his left. I perceived that though in reading he held the book at about thirteen inches from his eyes, yet upon my placing myself at the opposite end of the room (a distance perhaps of fifteen feet) he was unable to distinguish my features. An outline of a face alone could he make out. From the history of the case, and from the circumstances of his holding the book at the ordinary reading distance, there was but little doubt that the imperfection of vision was caused by loss of adjusting power.

My recommendation to him was to abstain from study, to visit the country, and whilst taking plenty of exercise, especially to strive to make out more and more distant objects. To provide himself with glasses two numbers lower than those he was using, and to employ even them only when absolutely necessary.

This gentleman called upon me nine months afterwards to say that he had derived great benefit from following this plan; he had passed much of his time in the open air, and his health was greatly improved. He began to perceive an amendment in the power of distinguishing distant objects in about six weeks after leaving town, and that power had steadily progressed; so that he could now recognise his friends across a tolerably wide street, and very rarely required the use of his glasses. He wished to know whether he might venture to resume his studies. I advised him never to read long without exercising his eyes in looking at distant objects; to study as little as possible by artificial light: to make a point of taking exercise every day, and never to put on his glasses when doing so, in order that the eyes might be kept in exercise as to distant objects.

Case VII. — A distinguished professional

friend, in the course of conversation upon the subject of loss of adjusting power, mentioned that when a student he had worked hard at dissection, and studied closely during the whole of one session. In consequence he lost the power of discerning objects beyond forty or fifty feet. The following summer he passed in the country, and before the commencement of the next winter session his vision had become perfect. By abstaining from too close application in future, the imperfection in his sight did not return; and although now advanced in years, he is in the enjoyment of excellent vision.

Case VIII.—In July, 1844, a young gentleman who had been reading for honours at one of our Universities, called upon me respecting a serious imperfection in his vision which he dated from the commencement of his close study. It appeared that he had been frequently in the habit of sitting up till three or four in the morning, studying intensely, besides much close application during the day-time. The only recreation he allowed himself was a short walk daily: he stated that his eyes felt hot and uncomfortable, with much itching, but what alarmed him was the discovery that from having had excellent vision, he had become quite near-sighted, rendering the

assistance of an eye-glass necessary; this he regretted being obliged to have recourse to, and wished to know whether any suggestion could be offered for his benefit. Upon a book being placed in his hand he held it about twelve inches from his eyes, at which distance he could see the type, but he said that he felt much inconvenience when walking the streets, on account of his inability to distinguish features or read the names upon the shops. Upon examination of the eyelids, chronic inflammation was apparent, but beyond this and some congestion of the superficial vessels of the eyeball, there was nothing unusual in the aspect of the eyes themselves; the pupils acted freely, and the irides were brilliant.

Upon his trying concave glasses, it appeared that the right eye required two numbers higher than the left, (no doubt from his having used the eye-glass,) but that numbers 4 for the left eye, and 6 for the right, afforded him good vision.

I recommended country air, exercise, and total repose from study: a mild alterative course was prescribed to correct the secretions, with cold ablution, followed by friction in the morning, and careful attention to diet.

He was advised to lay aside his eye-glass, to

be much in the open air, and to exercise his eyes upon distant objects.

After the expiration of four months, this gentleman called upon me and stated that he had been shooting in Scotland, that his health was quite restored, and his eye-sight greatly improved, although not as yet so perfect as it had originally been.

The popular idea that the eyes of near-sighted persons become less near-sighted as they advance in years, is certainly not borne out by experience. The subject has been investigated by Dr. Wells, whose acute mind was well qualified for such inquiries. He says,* "It has been very generally, if not universally asserted by systematic writers on vision, that the short-sighted are rendered by age fitter for seeing distant objects than they were in their youth. But this opinion appears to me unfounded in fact, and to rest altogether upon a false analogy. If those who possess ordinary vision when young, become from the flatness of the cornea or other changes in the mere structure of the eye, long-sighted as they approach to old age, it follows that the short-sighted must from similar changes become better fitted to see distant objects. Such ap-

* Phil. Transactions, 1811.

pears to have been their reasoning; but the course pursued by Nature seems very different from that which they have assigned to her. For of four short-sighted persons of my acquaintance, the ages of whom are between fifty-four and sixty years, and into the state of whose vision I have inquired particularly, two have not observed that their vision has changed since they were young, and two have lately become, in respect to distant objects, more short-sighted than they were formerly. I shall here relate the more remarkable of the two cases: A gentleman, who is a Fellow of this society, became short-sighted in early life, and as his profession obliged him to attend very much to minute visible objects, he for many years wore spectacles with concave glasses almost constantly; by the aid of which he saw as distinctly, and at as great a variety of distances, as those who enjoy the most perfect vision. At the age of fifty, however, he began to observe that distant objects, though viewed through his glasses, appeared indistinct, and he was hence led to fear that his eyes were affected with some disease. But happening one day to take up in an optician's shop a single concave glass, and to hold it before one of his eyes whilst his spectacles were on, he found to his great joy

that he had regained distinct vision of distant objects: with regard to such objects, therefore, he had become shorter sighted than he had formerly been. But along with this change another occurred of a directly opposite kind; for when he wished to examine a minute object attentively, such as he used to see accurately by means of his spectacles, he now found it necessary to lay them aside, and to employ his naked eye. The power consequently in this gentleman to adapt the eye to different distances is either totally lost or much diminished."

Case IX.—The following case is highly instructive, and illustrates in a remarkable manner the evil consequences likely to result from the improper use of glasses, and over exertion of the eyes in a constitution naturally exciteable. I give it in the words of the sufferer.* "I am now in my fifty-seventh year; my sight was originally near, but not distressingly so: at eighteen years of age I could read at the distance of twelve inches; about that age I became acquainted with convex glasses, and was so delighted with the distinct view and sharp outline they gave to

* A Case of Diseased Vision, by William Keir, Lecturer on Science. Lancet, Oct. 8th, 1842.

objects, that I began to wear them habitually when reading and writing, as well as when walking: the consequence was that I soon became much nearer sighted, and had to increase the depth of my glasses. This from time to time I continued to do, and I was distressed to find that with every increase of power my vision finally settled for reading at twelve inches, or within it; whilst every thing was as indistinct and ill-defined at a distance as before I began to wear glasses. The right eye I found to have not much more than half the focal distance of the left; in consequence, not only when the eyes are bare, but also when the glasses are on, objects appear double, the shadowy one being higher apparently than the other."

Mr. Keir then states that he has for many years been troubled with muscæ and occasional scintillations when in a state of irritation. In March, 1841, he made a sea voyage, and after landing, for several nights saw coloured coruscations and halos: he goes on to say, "The days were exceedingly bright, and for many hours each day I was engaged in reading or consulting a book which had a great deal of small print in it. This was done in a *white* room into which the sun shone brilliantly. In the evening, studies in

the same book were prosecuted with a small candle. I know not whether it was owing to the severity of the application, the brilliancy of the light in which it was conducted in the morning —the transition to the comparative gloom in the evening—or the state of the digestive organs, but at the end of a fortnight I became conscious of some apparent disorganization of the visual organs. The print would disappear and re-appear; an undulating cloud seemed to be floating before my eyes, with occasional openings in it; through the openings I could see the print distinctly, but it immediately became obscured, a denser part of the cloud intervening. I desisted from my close study, but if that had been the cause of injury, it was too late, for every object had the same clouded appearance: faces seemed to have black, ill-defined, large blotches on them; bright objects, as fire-irons, exhibited a tremulous undulating light and shade; the large white letters painted on a black ground on the ends of the streets became ill-defined and shaggy on the edge as if fringed with hoar frost. Besides the misty undulation and dark scaly-looking floating specks, a general dimness of vision had evidently been induced, for all my manuscripts and books appeared uncomfortably obscure and faint. As

light passing through glass is necessarily partly lost, I laid aside the use of glasses, to which I had been constantly habituated for thirty-eight years, and had rather more light to read by.

"Neither seclusion from light, nor low regimen, nor the severe depletion and physickings, to which for an attack of inflammation on the chest I was subjected, produced any sensible improvement in my sight.

"Recently I have not noticed the coruscations much, but often when I shut my eyes I observe a small bright light which gradually fades away. I should have mentioned that the retina throughout has been unnaturally retentive of impressions caused by faint impulses of light. I sometimes see the appearance of well-defined black roman capitals in the air, and sometimes I have a hasty evanescent glimpse of a whole word, as if printed in small greek letters; lines of print occasionally appear curved and actually undulating: so also do straight objects (especially if they be bright) when moved in a horizontal position. Rings, circles, and all circular and globular objects often lose their symmetrical appearance, appearing compressed and dimpled in every direction. The universal dimness appears almost uniformly

permanent, for though a gleam like that of sunshine sometimes illuminates an object, it instantly fades away."

These cases illustrate the affection of which I am speaking. The symptoms in all were the result of long-continued close application of the eyes upon near objects; there did not appear to be any material alteration in the focal length, for the reading distance averaged about twelve inches; the history, however, of four of the cases, clearly indicated that the eyes had been temporarily deprived of their due adjusting power. The point which I am desirous of impressing upon the reader is, that in cases such as I have described, spectacles are absolutely injurious; they afford, it is true, the means of discerning distant objects, but they tend to confirm the disorder, and render the individual dependent upon artificial aid for the remainder of his life. The course which ought to be pursued is plain; the patient should abstain from study and all pursuits requiring close application, and he should endeavour, by due and well-regulated exercise of the eyes, in the country if possible, to recover that adjusting power, of which, by injudicious exertion, he has deprived them.

I shall conclude this subject by narrating a singular case related by James Russell, Esq.

Case X.—"A gentleman," says he, "came to Edinburgh for a consultation on account of a severe complaint in his stomach. Previously to the commencement of this, he saw equally well with both eyes, and the focal distance of distinct vision was the same in each of them. A great change had, however, taken place in this respect, and what was remarkable was, that the change in the two eyes was in opposite directions. The focal distance of one having become longer and that of the other shorter than the original focal distance. But although the eyes no longer corresponded in their limits of distinct vision, each of them still retained the power of adapting itself to the variations in the distance of external objects, so far as its limits of distinct vision admitted.

"This affection was referred to the irritation excited by the gastric disorder, but as the patient returned into the country, the result of the case was not known."

CHAPTER III.

PRESBYOPIA, OR AGED SIGHT.

About the age of forty, the human frame begins to experience those changes which proclaim advancing age; one of the earliest indications of which, is an alteration in the refractive powers of the eyes, producing longsightedness or presbyopia (πρέσβυς, old, ὤψ, the eye). Dr. Kitchener has thus aptly described the premonitory symptoms of this change. "The first indication of the eyes beginning to be impaired by age is, that when you wish to read a small print, you are obliged to remove it farther from your eyes than you have been accustomed to do, and desire the aid of plenty of light; and, on looking at a near object it becomes confused, and appears to have a kind of mist before it, and the letters of a book run one into another, or appear double, &c., and by candlelight you catch yourself holding your book close behind the candle, and you begin to

admire the ingenuity of that gentleman who invented snuffers."

Facetious as is this description, it conveys a correct idea of the effect of the first of those constitutional changes which warn the individual that the prime of his life has passed.

It is in reading, or in working with the needle by candlelight, that the deterioration of vision is noticed, and surprise is often experienced that the eyes are now strained and fatigued by what had heretofore been an ordinary and agreeable occupation.

Various structural changes in the eye have been mentioned as giving rise to this presbyopic state.

1. A flattening of the cornea, from a diminution in the bulk, either of the aqueous or vitreous humours, or of both, the result of defective secretion.
2. An alteration in the consistence and diminution in the convexity of the crystalline lens.
3. Diminished density of the various humours.
4. Diminished curvature of the retina, which existing while the vertical diameter of the globe remains about the same, prevents the refracted rays that enter the flattened cornea from forming a picture upon the retina.

Whichever of the above may happen or exist,

the effect is to cause the converging rays of light to be brought to a focus beyond the retina, as shown in the figure, thus producing a confused and imperfect picture.

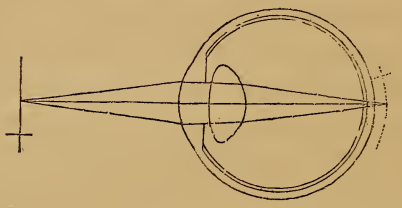

Fig. 10.

Distant objects are still seen distinctly without aid, inasmuch as the rays which proceed from them require less refractive power to bring them to a focus by the time they arrive at the retina.

Another change which the eye undergoes in age is the impairment of its power of adjustment. Dr. Mackenzie, in his able work,* truly says, "As we advance in life, not only do the refractive powers of the eye diminish, but we lose the power of accommodating the organ to near objects. The eye, in its state of perfect indolent vision, is adapted only to distant objects, and it cannot see near objects distinctly but by an

* Physiology of Vision by W. Mackenzie, M.D., p. 157.

effort. This effort long persevered in becomes painful, whereas the regarding of distant objects can be continued without any feeling of fatigue. The power to make the peculiar effort in question is partially or totally lost by the presbyopic eye: a fact analogous to the diminished activity which takes place in all the functions of the body as life advances."

The symptoms of presbyopia then are—

Difficulty in discerning close objects: so that a person who, in early life, could read ordinary print, with comfort, at twelve or fourteen inches, is now obliged to hold a book two feet, or even further from the eyes; and the act of threading a needle, or of nibbing a pen, becomes fatiguing to the eyes, if not almost impossible, excepting when assisted by an increase of light. Employing them at fine work, long together, induces headache and uneasiness about the brows and forehead.

These symptoms may be accounted for thus: in consequence of the object being removed to a greater distance, the visual angle, the quantity of light, and the picture on the retina become smaller; so small, indeed, as to render it difficult for the retina, with its impaired sensibility, duly to appreciate it without effort and a considerable

increase of light. The diminished size of the pupil too, which attends advancing years, frequently increases the necessity for more light.

There is usually little in the appearance of the eyes to account for these changes. This, indeed, might be expected, for although the cornea, in the majority of cases, is perhaps somewhat diminished in convexity, yet it is not perceptible. The inefficiency of the eye probably depends less upon the altered form of the cornea, than upon that of the other media of the eye, especially of the crystalline lens. The eyes of old persons are commonly sunken in the sockets; but this is dependant upon the general absorption of the adipose tissue of the orbits, as well as of the body generally, which is one of the phenomena of age. It is the diminution of the aqueous contents of the globe, in combination with peculiar changes in the lens, which becomes denser, less convex, of diminished transparency, and more or less of an amber hue, which influences the refractive powers. As age creeps on, the pigmentum nigrum (to which the blackness of the pupil is due) diminishes in quantity, giving to the pupil a greenish or greyish hue, which, to an inexperienced eye, might easily be mistaken for incipient cataract. The cornea becomes less trans-

parent, a white circle forms around its margin, called *arcus senilis;* the colours of the iris fade, and the nervous power of the eye becomes less energetic.

The period of life at which presbyopia displays itself, is the same as that at which *hard cataract* commences; and as it is possible that the imperfection of vision, arising from the commencement of hard cataract, may be confounded with presbyopia, by one who is not familiar with ophthalmic diseases, I will point out its distinctive marks.

Hard lenticular cataract is never found under the age of forty. The opacity usually commences at the centre of the lens. When facing the sunshine, or light, the patient complains that objects appear obscured, as by a mist. This obscuration is produced by the partially opaque lens arresting a portion of the light, and causing objects to appear as if seen through a bright thin cloud. When, however, the back is turned to the light, vision is greatly improved, because the dilatation of the pupil, which then takes place, exposes a large portion of the lens which is still clear, and vision is greatly improved; more light also, from the position, falls upon

the object looked at, and this again renders it more distinct. To obtain as much dilatation of the pupil as possible, the patients, when oppressed with too much light, knit their brows, and shade their eyes with their hand. The flame of a candle appears as if enveloped in fog, and the sharp outlines of objects are lost. Cataract may form in an eye previously presbyopic, in which case the symptoms now described will develop themselves, in addition to those which have been mentioned as characterising simple presbyopia.

A decided opinion as to the non-existence of cataract can only be ventured on with safety, after the pupil has been dilated with belladonna. When cataract does exist, it will generally be seen on dilating the pupil fully, as a greenish, greyish, or amber-coloured haze in the centre of the pupil; and of an opacity in proportion as the nucleus is hard. It is by no means unusual, when the iris is under the influence of this valuable drug, to find spots in the lens, or streaks extending from the circumference towards the centre; or even the whole margin of the lens opaque. Yet these changes will be concealed by the iris if the pupil is in its natural condition: much credit

has at times been gained for superior skill in the detection of cataract by simple attention to this one point.

Dilatation of the pupil is effected most rapidly, and for the longest time, by dropping into the eye a solution of the *neutral sulphate of atropine,** in the proportion of two or four grains to the ounce of distilled water. A full drop placed in the eye by means of a camel's hair pencil produces no pain. The lids should be closed for ten minutes, and the effect is usually produced in from fifteen to twenty minutes. I have known the pupil to remain under the influence of one application for eleven days. It should be borne in mind, that the preparations of belladonna have the effect of depriving the eye, for a time, of a portion of its power of adjustment. It is found that, as the dilatation of the pupil increases, the point of distinct vision is removed further from the eye. The inconvenience is, however, but temporary, but it is well that the patient should be warned of this effect, lest he imagine that the eye has been injured by the application of the belladonna.

* That which I use is prepared by Mr. Bullock, of Conduit Street. I have some in my possession which was prepared early in 1844, and it is yet perfectly good.

A general impression entertained by persons who find their sight failing is, that they require glasses. As, however, the deterioration of vision may be caused by commencing *amaurosis*, where glasses would be highly improper, it has been deemed advisable to state some of the chief symptoms of this disease..

The symptoms of amaurosis, or gutta serena, are as follows:—Objects are rendered dim by a haze or network before the eyes; spots, threads, lines, or strings of globules seem to be moving in the air, sometimes singly, at other times in great numbers, and under a variety of forms; lines of type appear confused and irregular; letters are distorted; they may be magnified, or they may appear diminished in size: double vision is a common and important symptom. Sparks, flashes, or circles of fire, annoy the patient, especially at night. Occasionally the flame of a candle appears to be surrounded by a coloured halo; in other cases it may appear broken up into two or more flames. In reading, some of the letters, or even words, are lost. There is generally dull pain felt in the head, the brow, or the eye itself; oftentimes there is pain down the side of the nose. The sight is best in a strong light, from the insusceptibility of the

retina, and the patients seek light by raising the brows and opening the eyes; which gives the staring look characteristic of amaurosis, as the contracted brow, and hand shading the eyes, is characteristic of cataract.

If the patient admits the existence of the above symptoms, or even of a large portion of them, there is disease, or at least disturbance, of the functions of the retina. It occasionally happens, however, that amaurosis takes place without the ordinary symptoms. A distressing instance recently came under my notice, of a gentleman who had undergone severe trials and much affliction, and who became blind apparently from simple loss of sensibility of the retina. The only account he could give was, that his sight became weak; day by day he saw less distinctly, until at length thick darkness came over his eyes, and in spite of every treatment, he became completely, and I fear hopelessly, amaurotic.

If we examine an eye in which amaurosis is commencing, the pupil, from the diminished sensibility to light, will be seen to act slowly and imperfectly. It may, from sympathy, contract briskly when the other eye is open, but if the healthy eye is closed, its motion will be

sluggish. It is proper, therefore, not only to compare the action of the pupils when the lids of both eyes are suddenly separated, but carefully to remark the action of the pupil of the suspected eye, when the lids of the other are closed.

I have considered it desirable to say thus much on the subject of amaurosis, for the information of those who are doubtful as to the propriety of beginning the use of glasses.

Mr. Ware states, that he has seen many instances in which old persons, who have been long accustomed to the use of convex glasses of considerable power, have recovered their sight at eighty or ninety years of age, and have been enabled to lay aside their glasses; similar instances have fallen under my own observation, and the probable explanation is that offered by Mr. Ware,—that, in consequence of the absorption of a portion of the vitreous humour, the sides of the sclerotic are pressed inwards by the action of the muscles; the effect being to lengthen the axis of the eye, by which the aberration becomes corrected.

Presbyopia is not confined to old age; it may be congenital.

Case XI.—An intelligent girl, eight years of age, was recently brought to me for an opinion.

Her grandfather stated, that she had always been remarkable for holding her book and work at a considerable distance from her. Upon examination, it appeared that the distance at which she held her book when reading, was twenty inches; nearer, she could not see distinctly. When threading a needle, she held it literally at arm's-length. Her vision for distant objects seemed to be excellent, and there was nothing unusual in the appearance of her eyes. A double convex glass, of thirty inches focus, enabled her to thread a needle at twelve inches distance; and with a lens of twenty-four inches focus, she was able to do so at eight inches. Concave glasses rendered vision indistinct. Her grandfather stated, that each of her parents required glasses at thirty years of age. The child was recommended to abstain from glasses; and there is good reason to believe, that as she grows older, and her eyes are more employed upon near objects, the distance of the point of distinct vision will decrease.

Case XII.—A lady under my care for incipient amaurosis, had been presbyopic from birth in the right eye, the left being of a natural focus.

Presbyopia may exist as a temporary condition.

Case XIII.—On the 17th April, 1840, a boy, eleven years of age, was brought to Edinburgh

from the country for the opinion of the late Dr. James Hunter. Fifteen days previously he was at school in perfect health, when one evening the discovery was made that he could not read common type, nor distinguish accurately any very small or near object. There was neither pain nor symptom of disease in either eye, but the vision of each was equally affected. The general health of the lad was unimpaired, and he had not received any injury either of the eyes or any other part. During the two following days the sight became worse, but after that it had remained stationary. Excepting the administration of some purgatives, no treatment had been adopted. Previous to the attack, his sight had been extremely good, and he had not been troubled with worms, or other ailment since infancy.

The eyes, upon examination, appeared perfectly healthy, and the only complaint made was, the inability to read common print, or to see minute and near objects: distant objects, he thought, were as distinct as ever (although it was subsequently ascertained that his distant vision was slightly affected). Large type was best seen at eleven inches from the eye; small print could not be read at all; distant objects were discerned pretty accurately; and the power of the two eyes

seemed equal. Concave glasses rendered his sight much less distinct, convex glasses improved it much.

Dr. Hunter strictly prohibited spectacles, and prescribed a combination of anthelmintic and tonic treatment, with spare diet and plenty of exercise in the open air. No worms made their appearance. The presbyopia continued until the end of May, when an amendment was perceived which increased daily, and in about ten days the sight was perfectly restored.

Case XIV.—*Presbyopia in young persons.*—A lad aged eight suddenly became presbyopic, but after the affection had continued a fortnight, it entirely disappeared under the application of leeches to the temples and the administration of purgative medicines.

Case XV.—Two sisters became presbyopic: the eldest, aged twenty, had never been able to do fine work, and for three years had used convex glasses. The youngest, aged fifteen, became presbyopic at fourteen, since which time she had used spectacles whenever she worked or read. She recovered in six weeks by the repeated application of leeches to the temples, but her sister, although she experienced much relief, was not entirely cured by similar treatment.

Case XVI.—*Presbyopic sight changed to myopic.*—In 1798, Mr. Ware met Sir Walter Farquhar to consider the case of a lady on account of a very considerable mist which she constantly perceived before her right eye. The sight of her left eye had long been imperfect, and the present dimness of the right eye, which had continued a fortnight, followed a cold which affected her head, but had not produced any considerable inflammation of the eye itself. She appeared to be a strong healthy woman, but had suffered much from anxiety shortly before the dimness of sight came on. On account of the depressed state of her spirits she had taken volatile medicines; but these had produced a disagreeable heat on the skin and rather an increase of the dimness. It was doubted whether the disease proceeded from nervous debility, or from an inflammatory diathesis, but an antiphlogistic course of treatment was decided on. Mr. Ware opened the vein on the right side of the nose and abstracted four ounces of blood, and a purging mixture was prescribed; animal food and all excitement were prohibited. The eye was ordered to be fomented thrice a day with weak brandy and water, and the precipitate ointment to be applied at bed-time. On the following day

the eye was much the same. Counter-irritation was now applied to the back and a cooling laxative prescribed to be taken every six hours. On the third day an improvement was perceptible, and in a week the mist was removed, but the pupil continued of one fixed size in all degrees of light. A preparation of bark was now ordered. Shortly after this the lady went in the country, the right eye being perfectly free from any defect of sight, but it had undergone an extraordinary change, for she was now able to see near objects without the aid of convex glasses, which she had always before required, and distant objects appeared so confused that she was obliged to use a number six concave glass whenever she wished to discern such objects distinctly.*

Case XVII.—*Myopia succeeding presbyopia.*—A gentleman, sixty years of age, who had spent a great part of his life in the West Indies, and whose sight, when young, enabled him to distinguish both near and distant objects with great precision, began at the age of forty to experience a difficulty in reading and writing. He immediately procured convex glasses of the lowest power, and by their aid he continued to read and write with ease, (distinguishing per-

* Chirurgical Observations relative to the Eye, by James Ware, vol. ii. p. 164.

fectly all distant objects without them,) until he was fifty. At this time he began to perceive an indistinctness in the appearance of distant objects, and on trying different glasses, he discovered that by looking through a double concave glass (number six), he was enabled to see distant objects distinctly. He continued to use glasses of this description for the purpose of seeing distant objects from that time to the period of his consulting Mr. Ware, but was obliged to remove them and employ the convex glasses above mentioned for reading or writing.

Case XVIII.—*Myopia succeeding presbyopia.* —A woman 50 years of age, of a full habit, who for several years had been obliged to make use of convex glasses in order to read small print, was seized with a dimness in the sight of the right eye, accompanied with a small degree of inflammation. Recourse was immediately had to copious evacuations, by means of which the inflammation and dimness of sight were soon removed; but afterwards the patient was much alarmed on finding that the spectacles she had been accustomed to wear, instead of affording their usual assistance, confused her sight; however, upon looking through her husband's myopic glasses, which were double concaves, she saw

distant objects much better, although they did not assist her in looking at near objects, but she was enabled to read by bringing the book a little nearer to her than she had been previously accustomed to place it.

Case XIX.—*Presbyopia succeeding myopia.*—A lady who had been subject to muscæ volitantes of an aggravated character, consulted Mr. Ware on account of her discovering that she was unable to read with her left eye. Mr. Ware could not detect any unnatural appearance in the eye, but upon desiring his patient to read, observed that she held the book at a considerable distance, which was the more remarkable as the eye had previously been myopic. It was now evidently presbyopic, and on holding a convex glass of thirty-six inches focus before it, vision became distinct and the smallest characters were read without difficulty. Notwithstanding this sudden change in the sight of the left eye, the right continued myopic and required a concave glass to enable it to discern distant objects. As the lady was far advanced in pregnancy and of a full habit, Mr. Ware recommended the abstraction of ten ounces of blood from the arm, and prescribed cooling medicines. By this treatment the presbyopic condition of the left eye was in a

short time removed, and the right became somewhat less short-sighted.*

Case XX.—A lady, about fifty, was attacked with an inflammation in both eyes which was speedily removed by leeching and purgatives: she was then much gratified by finding that the necessity for using glasses when she read, which had existed many years, was removed, and that she could see both near and distant objects correctly without any extraneous help. The amendment was, however, only temporary, and after a few weeks she was obliged to have recourse to her convex glasses for seeing near objects, the same as before the attack.

An eminent mathematical instrument-maker, who had long used convex glasses for reading, told Mr. Ware that on many occasions, after he had been engaged for some hours daily for weeks together in looking through a microscope, he has been able to read without his glasses for some weeks, but that the amendment gradually abated.

Case XXI.—*Presbyopia occurring in combination with ptosis.*—The following case is related by Dr. Wells. "I was consulted in the

* Medico-Chirurgical Transactions, vol. v. p. 263.

beginning of 1809 upon a disease of vision which, as far as I know, has not hitherto been mentioned by any author. The subject of it was a gentleman about thirty-five years old, very tall, and inclining to be corpulent. About a month before I saw him he had been attacked with a catarrh, and as this was leaving him, he was attacked with a slight stupor and a feeling of weight in his forehead. He began at the same time to see less distinctly than formerly with his right eye, and to lose the power of moving its upper lid. The pupil of the same eye was now also observed to be much dilated. In a few days the left eye became similarly affected with the right, but in a less degree. Such was the account of the case which I received from the patient himself, and from the surgeon who attended him. The former added, that previously to his present ailment his sight had always been so good that he had never used glasses of any kind to improve it. On examining his eyes myself, I could not discern in them any other appearance of disease than that their pupils, the right particularly, were much too large, and that their size was little affected by the quantity of light which passed through them. At first I thought that their dilatation was occasioned by a

defect of sensibility in the retina, but I was quickly obliged to abandon this opinion, as the patient assured me that his sensation of light was as strong as it had ever been during any former period of his life. I next inquired whether objects at different distances appeared to him equally distinct: he answered that he saw distant objects accurately, and in proof told me what the hour was by a remote public clock; but he added that the letters of a book seemed to him so confused that it was with difficulty he could make out the words which they composed. He was now desired to look at the page of a printed book through spectacles with convex glasses. He did so, and found that he could read it with ease. From these circumstances it was very plain that this gentleman, at the same time that his pupils had become dilated and his upper lids paralytic, had acquired the sight of an old man by losing suddenly the command of the muscles by which the eye is enabled to see near objects distinctly."

Treatment.—The sun of our animal existence has been wisely ordained to travel at so slow a rate, that his progress is almost imperceptible; and so ardently do we love to bask in his rays, that when time whispers to us he has passed the meridian, we vainly endeavour to persuade

ourselves that he may have mistaken the point of his culmination.

We have already said that the failure of the sight is one of the earliest premonitory symptoms of declining years, but there is often a strong disinclination to admit this failure; at any rate we are not willing to proclaim it by adopting glasses. Their use, however, should not be deferred; for although it is a common notion that spectacles are injurious to the eyes, (and no doubt they are so if those of an improper description be employed)—yet when the powers of the eye so begin to fail that we can neither read nor write for any length of time without great discomfort, it is reasonable to conclude that refraining from their use is more injurious than their adoption. We therefore, who prize the most valuable gift of nature, should be less anxious as to what others may think of our age, than for the preservation of so valuable a possession.

The term "preservers" applied as it has been to the lowest description of convex glasses alone, tends to convey the idea that if such glasses are used in time they prevent any further changes in the eye. This is erroneous, and it is to be regretted that the lowest magnifying powers should have received that appellation, for all

glasses are "preservers" if well adapted to the wants of the eye, whereas by applying that term to those particular glasses alone, thousands are induced to use them before they really require them, which is productive of injurious consequences, inasmuch as by assisting the eye before it needs help, we encourage it to be indolent in its action. As a general rule for the presbyopic eye, glasses always act beneficially when they afford just so much assistance to the eye in its attempts at adjustment, as enables it with but little fatigue to form a distinct picture upon the retina, rather than beyond it, as shown in the the figure.

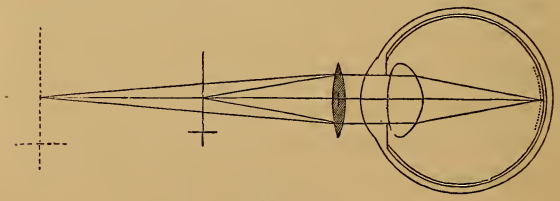

Fig. 11.

Some refrain from the use of glasses who really require their aid, from the belief that if they once begin to use them they will never be able to leave them off. In the great majority of cases this is perfectly true; but even then it is better to submit with a good grace to an affliction which can

seldom be averted, and to have recourse to those simple means which at once set the eye at ease, and enable its possessor to enjoy many hours of comfort and rational employment which would otherwise be lost.

Daily experience teaches us that the decay of vision is hastened by many causes which are frequently overlooked. Although it is about forty that the sight usually begins to fail—yet we find that some persons attain extreme old age without needing glasses at all. A respected friend of mine who for many years held a distinguished position in the public service, can now, in the eighty-fourth year of his age, see to read and write with as much facility as he could fifty years ago; he has never used glasses, nor will he probably ever require them. Other persons, on the contrary, require glasses by the age of thirty, and though much depends upon constitution, much also depends upon a person's habits.

One of the worst of habits is that of overworking the eyes by candle-light at night. Repose from labour, so necessary for the restoration of tone and vigour to the several organs of the body, is too sparingly granted to the eyes. Some from a desire to distinguish themselves, others urged by necessity, encroach upon the

hours of rest and overtax the sight without mercy, by lamp or gas-light. To the poor but working classes, medical treatment, when the eyes are thus oppressed, affords only temporary relief; the return to similar habits however necessary, invariably brings back the same disease, and by its repeated attacks vision is sooner or later destroyed. Let us hope that the advancing spirit of the age will speedily arrest so crying an evil.

The following remarks are addressed to the former class: to those, who from motives of ambition, or from love of study, neglect those ordinary precautions without which the eyes will inevitably suffer. Let it be remembered that day-work is preferable to night-work: that while the light of a candle or lamp is trying even to a strong eye, the moderate light of the sun is strengthening to it. Those whom circumstances compel to study in the evening, should select that kind of work which is least distressing to the eyes: they should especially avoid indistinct writing or small print. The "Diamond editions," in which the print is extremely small, are very hurtful to the eyes. I have a volume of Burns' Poems thus printed, and if I attempt to read it, my eyes feel strained, and the appearance of muscæ volitantes is excited before I have perused half a page.

Reading by firelight, or simply gazing at the fire when sitting alone, or in a contemplative mood, is highly injurious to feeble eyes, and should be avoided by all. It is not advisable to read by twilight; too little light is as pernicious as too much light, yet many persons will, evening after evening, try their eyes in this way rather than burn a candle. It is injurious to the eyes to be long exposed to the reflection of a strong light, whether artificial or natural, such as the reflected sunshine from the page of a book. Too brilliant a light produces undue excitement of the eyes: travellers in the African deserts find it necessary to protect these organs from the sun's rays by a piece of crape. The inhabitants of some Eastern Countries, for the same purpose anoint the edges of the lids and the eyelashes, with a black pigment composed of oxide of antimony and oil, which has the effect of subduing the light, and at the same time improving personal appearance. The inhabitants of the Arctic regions ingeniously protect their eyes from the light reflected from the snow,* by wearing in front of the eyes a long and thin piece of wood perforated by two narrow horizontal slits, one

* Appendix C.

corresponding to each eye. By means of this simple contrivance, just such a quantity of light is permitted to enter the pupil as will suffice for vision. To preserve weak eyes as much as possible from a strong light, neutral tint spectacles are exceedingly suitable.

In reading and writing, just that amount and quality of light, whether natural or artificial, should be allowed, which while it thoroughly illuminates the object, feels grateful and pleasant to the eyes. This desideratum can never be obtained without due regard to the position of the light. The light cast upon a book while the candle is in front, is by no means pleasant, and the glare of the flame is very trying to weak eyes. It will be found, that if the candle or lamp be placed behind the reader, a little elevated and slightly on one side, the pleasantest and least injurious effect is produced; for the light then reflected to the eyes is less distressing, and at the same time the eyes are perfectly protected from the heat and glare of the flame.

It would be well if in our public buildings more attention was paid to the position of the lights: it is very distressing to sit in a gallery immediately opposite the glare of a gas burner or lamp, for an hour or more; the eyes fre-

quently do not recover from the irritation thus excited for several days—not only might the evil be easily removed by employing lights of greater power and placed nearer the ceiling, but there would be a great advantage gained from the increased purity of the air.

Sudden transitions from gloom to strong light should be avoided. The dazzling effect produced when we come suddenly from darkness into light, arises from the pupils having been widely dilated to admit the greatest possible number of luminous rays whilst in the gloom; and as the pupil of the eye requires time to contract, sudden transitions from comparative darkness to a bright light, compels the eye to admit far more rays than is either agreeable, or than it is calculated to bear without injury: temporary dazzling and a sensation of pain is excited in consequence. So weak and susceptible do the eyes become if kept for a long time in darkness, that the ordinary light of day is distressing to them. I have frequently been consulted by patients labouring under this morbid sensibility, sometimes from having been kept for a long time in a darkened room, at other times from having injudiciously covered up the eyes with a bandage or shade in the hope of subduing an inflammation. The working

classes are fond of binding up their own eyes, or those of their children if attacked with any disorder, whether attended with increased sensibility to light or not, and it is difficult to convince them of the necessity of taking the bandage off, and by degrees accustoming the eyes to the stimulus of light.

The late Sir William Herschell, when sweeping the heavens with his forty feet telescope in search of nebulæ, used to shut out the light from surrounding objects by means of a black hood, to increase the sensibility of the retina; and so effectually did he succeed, that with his eye so prepared, when a star of the first magnitude approached the field of view it was needful for him to withdraw his eye from the telescope until it had passed, otherwise that sensibility would be lost for some time. When Sirius approached the field of view, the appearance of the sky was to his eye like the dawn of morning, gradually increasing in brightness till it had attained a splendour resembling that of the rising sun, compelling Sir William to retreat from the glorious spectacle.*

* Galen in his tenth book "De usu partium" tells us that Dionysius, the tyrant of Syracuse, used to bring forth captives from dark dungeons, into a brilliantly lighted room, and the

To supply the defective powers of the presbyopic eye, convex glasses are used, and the double convex are preferred. The lowest power is ground to a focus of forty-eight inches, and affords sufficient aid for some time after the eye becomes first affected. It is seldom, however, that the surgeon is consulted before the eye requires glasses of thirty-six inches focus.

effect of this sudden and powerful transition was to render the miserable wretches blind.

Similar effects, though not from similar motives, were produced at Paris in 1789, at the destruction of the Bastile, when some of the unhappy persons who had been confined for years in its dark subterraneous dungeons, were blinded by being incautiously brought in their feeble state into the full blaze of a July day.

Sir David Brewster observes (Martyrs of Science, p. 49) that "It does not appear from the history of solar observations at what time and by whom, coloured glasses were first introduced for permitting the eye to look at the sun with impunity. Fabricius was obviously quite ignorant of the use of coloured glasses. He observed the sun when he was in the horizon, and when his brilliancy was impaired by the interposition of their clouds and floating vapours: and he advises those who may repeat his observations, to admit at first to the eye a small portion of the sun's light, till it is gradually accustomed to its full splendour. When the sun's altitude became considerable, Fabricius gave up his observations, which he often continued so long that he was scarcely able for two days together to see objects with their usual distinctness."

It cannot be too strongly urged upon any one about to use spectacles for the first time, that that power which will enable him to read without much exertion by candlelight, is the only power suitable for him. It is by candlelight only he should use glasses at first, and so soon as he finds that he stands in need of glasses by day as well as by candlelight, and that the glasses he uses, no longer afford him sufficient assistance by candlelight, it will be proper to use the next power for the evening, but for the evening only, and to allow himself the use of the others—and their use only—during the day. The greatest caution as to increasing the power of glasses should be observed, for persons who change their glasses unnecessarily, increasing their power each time, are exhausting the resources of art instead of economising them as much as possible. Optical aid can only be extended to a certain point, and the steps to that point should be as slow and as numerous as possible. By exercising prudent precautions, persons may often attain great age, and yet never require the aid of glasses beyond a very moderate power: others on the contrary, who from ignorance frequently increase the power of

their glasses, may run through the whole assortment, and leave themselves only the most inconvenient resources to fall back upon—viz. the very highest powers.

CHAPTER IV.

GLASSES.

In order that the action of spectacles may be clearly understood, I will, before entering upon the subject, explain the effect of the different kinds of lenses upon rays of light.

There are six varieties of the common lens:

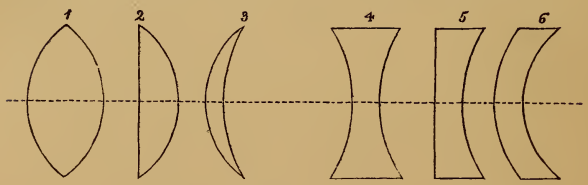

Fig. 12.

1. The *double convex lens* is bounded by two convex spherical surfaces, each of whose centres is in the axis of the lens only on the sides opposite to their surfaces.
2. The *plano convex* has one side convex, the other plane.

3. The *meniscus* has one surface convex, the other concave, and the surfaces meet if continued.
4. The *double concave* is bounded by two concave spherical surfaces whose centres are on the same sides of the lens as their surfaces.
5. The *plano concave* has one surface plane, the other concave.
6. The *concavo convex* has one surface concave, and the opposite convex, but these do not meet if continued.

The first three magnify.

The following is a short demonstration of the principles of action of concave and convex lenses :

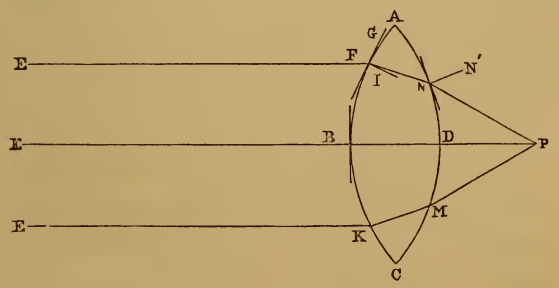

Fig. 13.

Let A B C D fig. 13 be a transverse section of a

double convex lens, and E F, E B, E K, parallel rays of light falling upon such lens. As the ray E B falls at right angles to the tangent of the arc A B, it passes straight through the lens in the direction B D in a straight line with E B.

But the ray E F, on passing into the lens, that is from a less to a more refracting medium, and in a direction not at right angles to the tangent F G, is refracted towards the line I F which is perpendicular to the surface of the lens at the point at which the ray E F entered. Having traversed the lens it undergoes a further refraction on leaving it, but in this case, because it is leaving the more refractive, and entering a less refractive medium, it is refracted from the perpendicular N N′ in the direction N P, and meets the axis at P, which is the focus. If the lens be of glass and equi convex, the distance of the focus behind the lens will be equal to the radius of either of its surfaces; the effect therefore of a convex lens is to render parallel rays convergent.

The action of concave lenses upon light is precisely the converse of the action of convex lenses. Concave lenses render the rays *divergent.*

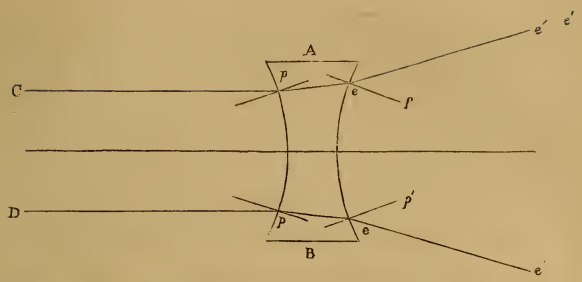

Fig. 14.

A B (fig. 14) is a transverse section of a double concave lens—C and D are parallel rays incident upon it. These rays on entering the lens are refracted towards *p p*, the perpendiculars to the surface at the points at which the rays C and D entered, and on leaving the lens they undergo a further refraction: in this case from *p' p'* the perpendiculars to the surface at the points at which they emerge, that is, they will diverge in the directions *e*, *é*, *e*, *è*.

The merit of having been the inventor of spectacles is by many given to Roger Bacon; however that may be, they were certainly known at the time of his death. Alexander Spina, of Pisa, who died in 1318, is said to have constructed a pair; and Muschenbroek states, that there was an inscription on the tomb of one

Salvinus Armatus, a noble of Florence, who died in 1317, to the effect, that he was the inventor of spectacles. There seems to have been no distinct rules as to their application until the time of Maurolicus of Messina, who lived about 1575, and he, it was, who pointed out the real cause of myopia, and presbyopia, and explained how concave glasses rectified the former, and convex glasses the latter. To him, and to his predecessors, mankind owe a debt of gratitude; for it is not too much to say, that through the aid of spectacles, we continue to use, till old age, one of the most noble and valuable of our senses; through them the mechanic continues his labours, and earns a subsistence by the work of his hand till the extreme of old age. By their aid the scholar pursues his studies, and recreates his mind with intellectual pleasures, and thus passes away days and years with delight and satisfaction, that might otherwise have been devoured by melancholy, or wasted in idleness.

I shall, in the first instance, describe the mode in which spectacles are made, and after that proceed to their application.

The glass principally employed for spectacle lenses is plate glass of the purest quality; that called "*British plate,*" is preferred, as combining the greatest number of good properties.

The mode of making spectacle glasses and lenses generally, is as follows :—

A piece of glass, of a thickness proportionate to the convexity or concavity of the intended lenses, is cut into small squares with a diamond; after these small squares have had their corners snapped off, they are fixed with cement to a metal tool, the concavity or convexity of which corresponds to the curve they are intended to receive.

They are then worked by hand, or machinery, on the smoothing tool, which latter must be perfectly true, and of a radius in accordance with the focal lengths of the intended lenses. They are worked with a peculiar kind of eccentric motion, which is found to give equal friction to all parts of the surface. After the lenses have been thus gradually ground into shape, and smoothed by emery powder of different degrees of fineness, prepared for the purpose, they are subsequently polished with oxide of tin, commonly called *putty*, which is laid on a polisher made of felt and cement, and formed to the curve of the smoothing tool. When one side of the lens is completed, the other side is subjected to a like process, and when both sides are perfectly

polished, all that is required is to cut and grind the edges to fit the spectacle frames.

There is a common prejudice in favour of pebbles, but whilst their chief merit consists in their being so extremely hard, that it is difficult to scratch or break them, they have the disadvantage of being expensive, partly on account of the additional labour in making them, partly from the number of imperfect ones met with during their manufacture, whereby the price of good pebbles is enhanced.

The neutral tint flat glasses are so ground, that the two flat and polished surfaces are parallel to one another. Glasses of all tinges of blue and green are to be found in the opticians' shops, yet there can be but little doubt that the hue is the least injurious to the eyes, which is termed the *neutral tint*, and for the following reasons:—

When the eye, after having been strongly impressed with any particular species of coloured light, is directed to a sheet of white paper, it will not be capable of determining, for some time, that the paper is white, neither will it attribute to the paper the colour with which the eye was impressed, but a different colour, which is called its accidental, or complementary colour. The fol-

lowing is a table of the colours, and of those which are complementary to them.

Colour.	*Complementary Colour.*
Red	Blueish green
Orange	Blue
Yellow	Indigo
Green	Violet reddish
Blue	Orange red
Indigo	Orange yellow
Violet . . .	Yellow green
Black	White
White . . ,	Black.

Thus, then, when the eye has been for some time looking through a blue glass, the retina becomes less sensible to blue light. Consequently, the moment the blue glass ceases to be used, the retina being less sensible to the blue rays which form part of the white light flowing from the paper, the paper will appear of that colour which arises from the combination of all the rays in the white light which it reflects, with the exception of the blue, that is, it will appear *orange red.* In like manner *green* will excite a *violet red* spectrum. As coloured glasses are almost always made use of to screen the eyes in cases where there is undue sensibility of the retina, any thing which

unnecessarily blunts the sensitiveness of that membrane (such as a particular colour,) though temporarily, should be avoided. It is on this account that the neutral tint glasses are to be preferred, from being, as the name implies, of no definite colour. They screen the eyes from all colours alike, and produce, in sunshine, the effect of a cloudy day, which is exceedingly grateful to weak and irritable eyes.

The desire to conceal from the world any imperfection which wounds our self-love, is inherent in the human heart, and leads to all sorts of artifices on the part of those who, by natural conformation, advancing years, or other causes, suffer from imperfection in their vision.

Thus it is, that some persons prefer to use an eye-glass, others reading glasses, in lieu of spectacles. Reading glasses, however, are objectionable, from their not being firmly fixed in front of the eyes. The motion of the head not being in accordance with that of the hand which holds the glasses, has the effect of trying the eyes exceedingly in their constant and ineffectual endeavour to adjust themselves to the position of the glasses, inducing unnecessary fatigue to the eyes, and rendering necessary an earlier resort to

glasses of a higher power than would have been required had proper spectacles been adopted from the commencement.

But a single eye-glass is more injurious still; and many young men, who, from shortness of sight, or a singular vanity, have thought proper to use a quizzing glass (as it is termed) have had reason to regret it to the end of their lives. I am acquainted with a gentleman, the sight of whose right eye has been seriously impaired, from his having, in early life, constantly used one of these eye-glasses, and numerous other instances have come to my knowledge. The consequences to perfect vision are serious, for as one eye is made to do more work than the other, an alteration in their relative strength takes place; the result is, that sooner or later, when the person resorts to spectacles, he finds that the lens which suits one eye will not at all suffice for the other.

Watchmakers, and other artists, who work with a magnifier, are very subject to this imperfection of vision, and generally find that they see better with one eye than the other. If, instead of always applying the magnifying glass to one eye, they were to use the other eye in turn, a habit

which might be easily acquired in early life, although with difficulty afterwards, they would preserve the power of their eyes more equally, and the perfection of vision longer; for, by using the eyes alternately, rest, and an opportunity of recovering from the fatigue produced by the exertion of looking through the magnifier, would be afforded to each. In like manner, those who indulge in microscopical or astronomical pursuits, should learn to use either eye indifferently, instead of always trusting to one, although we almost instinctively apply the right eye to a telescope or microscope.

An eminent optician informed me that, from constantly looking through microscopes, &c. with his right eye, the focus of that eye has been rendered so much longer than that of the left, that whilst the left eye is suited by a glass that is perfectly plane, the right requires a lens of 36 inches focal length.

There are three varieties of lenses in common use for spectacles. The double concave for shortsighted persons, the double convex for long or aged sight, and a third description, invented and patented by Dr. Wollaston, to which he applied the term *periscopic;* so called, from the

facility they were supposed to afford for looking round at various objects, without turning the head, and so giving a wider field for vision. They were also intended to obviate the defect in common lenses, that no object appears distinct through them, except such as are seen through the centre of the lens. Dr. Wollaston conceived that, by making each side concave towards the eye, each portion of its surface might be nearly at right angles to the axis of vision, and would thus render lateral objects distinct, without impairing the distinctness of those seen through the centre. This effect for farsighted persons he accomplishes by means of the meniscus with the concave surface next the eye, and for shortsighted persons he adopted the concavo-convex. There can be no doubt that the advantage of a wider field is gained in proportion as the second surface of the lens approaches to the form of the curvature of the cornea, but this is scarcely necessary, as we generally turn the head to look at an object, instead of glancing at it obliquely. To persons who are in the habit of regarding objects thus obliquely, periscopic glasses would be applicable, but they do not render vision so distinct as ordinary lenses,

and they increase (although in a very trifling degree) the aberration both of colour and figure; therefore the double concave or convex lenses are to be preferred to the periscopic.

It occasionally happens that lenses have to be ground of an unusual form to meet peculiarities of vision. The Astronomer Royal, Professor Airey, requires such a lens in consequence of an imperfection in the refractive powers, either of the cornea or of the crystalline lens of one of his eyes giving rise to double vision with that eye. The Professor finds that his eye refracts the rays to a shorter focus in a vertical plane than in a horizontal one, and to procure a distinct picture on the retina, he has ingeniously contrived a lens, one surface of which is a spherical concave, and the other a cylindrical concave. The common concave is to remedy the usual effect of a convex cornea, and the cylindrical concave, when placed with its axis horizontal, and at right angles to the axis of vision, gives to the eye a set of vertically diverging rays to be refracted, whilst horizontally it does not diverge them. Thus offering to the eye just so much more to do vertically, as the extra vertical curvature of the

cornea requires it to have to enable it to bring all the rays to a focus at once.

Great judgment and discrimination are required before giving a decision as to the propriety of a patient having recourse to spectacles, and many points should be borne in mind before assenting to their use. We should first satisfy ourselves that the impairment of vision does not arise from diminished sensibility of the retina, and that the case is not one of incipient amaurosis: if it be so, the temporary comfort occasionally afforded by the aid of glasses will be purchased at the price of more speedy extinction of vision; and we discover, when too late, that measures very different to those recommended would have been the means perhaps of rescuing the individual from the horrors of blindness. If the case is supposed to be one of myopia, we should carefully ascertain that the defective vision arises from an alteration in the powers of the refractive media, and is not the consequence of the eye having lost the power of adapting itself to the focus for distant objects.

In the latter case we should commit a grave error in recommending glasses, for as I have explained elsewhere, their employment is absolutely injurious.

Amongst the lower classes, nearsight, unless it be in a marked degree, is but little regarded, and the individuals make increased exertions to distinguish distant objects without troubling themselves about spectacles; by so doing they frequently overcome the imperfection in their vision, or at all events prevent its becoming greater. But persons in the higher ranks of life, no sooner discover a trifling imperfection in their vision than they have recourse to artificial aid, and thereby render permanent a defect which might perhaps have left them altogether.

Having made these preliminary remarks, I will proceed to the subject of choosing spectacles.

There cannot be a greater error than in purchasing cheap and imperfect spectacles; such frequently are those which are advertised as possessing remarkable and peculiar qualities. The mode in which glasses act is simple, and has been already noticed. The rules for their selection are equally simple, but of paramount importance. After ascertaining that the glasses are perfectly free from specks or veins, by moving them backwards and forwards between the eye and the flame of a candle; the next point of importance to be attended to is, whether the figure of the lenses is accurate. This may be ascertained

by moving each glass backward and forward between the eye and the page of a book. If the lens has not been completely ground, or the material is not homogeneous, the characters will appear distorted. Another point of great importance is to select the lowest power that is productive of distinct vision. The glasses, of whatever description, when placed near the eye, should give a blackness and distinctness to the letters of a book without enlarging or diminishing them, or exciting the least sensation of straining or fatigue of the eye. The glasses employed in myopia are *double concaves*, and each side should be accurately ground to the same curve. We should, (as in presbyopia,) select glasses of the lowest power, or in other words, those in which the surfaces are portions of the largest spheres; and so long as these enable the person to distinguish the outlines of objects distinctly at about forty or forty-five feet, he should not have recourse to a higher power; for if he rashly increases the power, or if he begins with one that is too powerful, he will not only find it difficult to go back, but that the tendency of the eye to crave a higher power will still remain. Persons are frequently induced by the pleasure they derive from looking at objects through a high power, to have recourse to that power; at first

it certainly renders objects clearer, and defines them more sharply, but after a time this effect passes away, and a still higher number is sought after; for although the eye will become accustomed to undue and continued excitement, yet its susceptibility is diminished thereby, never perhaps to be restored.

Another point which all should attend to in selecting spectacles, is to look through each glass, with each eye, separately, at small print, and carefully to ascertain whether the effect upon each eye is the same from each glass; should it happen, as is not uncommon, that the focal power of one eye differs from that of the other, the inequality will thus be discovered.

There is one point of considerable importance which is seldom regarded,—viz., the fitting of the spectacle frame, so that the centre of each glass shall be exactly opposite to the pupil of the corresponding eye. A moment's reflection will show how important this is. There are scarcely two persons of precisely the same width between the eyes, and yet in the majority of cases this fact is entirely lost sight of in the selection of spectacles. A person finds that, when at an optician's he looks through a lens of a certain power, it suits him exactly: he sees delightfully with it,

and forthwith orders spectacles of that power. He tries them on as soon as he receives them, anticipating with eagerness the comfort they will afford him; instead of which, he finds that he can hardly see at all, or if he does, his eyes soon feel fatigued. The glasses are right, the error is in the frame. Unless the width between the eyes is such, that the centre of each glass is exactly in front of the eye which it is to assist, the rays that pass through the lens will not all enter the pupil, and the spectacles will be comparatively valueless. Care should be taken then, in every case, to have the bridge made of such a curve and such a width, that the position of the lenses as regards the eyes shall be perfect, both horizontally and vertically.

The three most usual forms of spectacle frames are represented in the following figures. The first (fig. 15) is that commonly used for Presbyopic glasses. The second (fig. 16) brings the glasses near the eyes. The third (fig. 17) is sometimes preferred, as being generally useful.

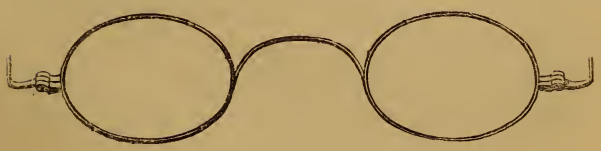

Fig. 15.

Fig. 16.

Fig. 17.

I have mentioned the curve as well as the width, for by it the height of the glasses is adjusted. Shortsighted persons require the glasses to be nearer the eyes than do the farsighted, and this is to be regulated by a peculiar kind of curvature of the bridge, a curvature in two planes rising vertically and projecting out at the same time,—as shown in fig. 16. It may be as well here to notice, that whenever the frames are well fixed, the two eyes appear, to the individual, to be looking through one glass only.

Before spectacles are finally decided upon, they should be worn for a day or two in order that

they may be fairly tried, for the eyes become so excited by looking through a variety of glasses, that it is almost impossible to discover at once what power is really most suitable.

The material best adapted for spectacle frames is blue steel, which combines the advantages of lightness, elasticity, durability, and neatness of appearance. The brilliancy of gold and silver frames is objectionable, as tending to dazzle the eyes, and from this the blue steel frame is free. Some persons prefer tortoiseshell frames, but these have a heavy appearance, and are very liable to be broken. If, however, fancy inclines towards them, care should be taken that the front is all black, because if it is made of variegated shell, the dazzling will be even greater than that from the gold or silver. The front of the frame should be made to project sufficiently far beyond the glasses to protect them from friction in drawing them in and out of the cases, or from being scratched when laid flat down. Many persons are very careless as to this; leaving their spectacles about, allowing them to become dim with moisture and dirt, and wiping them with the first thing that comes to hand—their coat-tails or pocket handkerchief; but if they wish to keep their glasses in a good state, they should be

sedulous to clean them with wash leather that has been freed from the yellow ochre used to colour it, for this offers less risk of scratching the glasses than does silk, or any other material.

Spectacle lenses are best distinguished by their focal lengths. The following are the focal lengths of double concave and double convex glasses made by the eminent optician Mr. W. Hawes:

Double concave (Myopic.)		Double convex (Presbyopic.)
No. 00	about equal to	42 inches focal length.
0	. . . . .	30
1	. . . . .	24
2	. . . . .	20
3	. . . . .	16
4	. . . . .	14
5	. . . .	12
6	. . . . .	10
7	. . . . .	9
8	. . . . .	8
9	. . . . .	$6\frac{1}{2}$
10	. . . . .	$5\frac{1}{2}$ *
11	. . . . .	$4\frac{1}{2}$
12	. . . . .	4

* The lens of $5\frac{1}{2}$ inches focal length is the highest power usually required by eyes which have not undergone operation for cataract. The $2\frac{1}{2}$ inch focus are the double convex glasses generally supplied to cataract patients.

13	$3\frac{5}{8}$
14	$2\frac{3}{4}$
15	$2\frac{5}{8}$
16	$2\frac{1}{2}$
17	$2\frac{2}{10}$
18	2
19	$1\frac{3}{4}$
20	$1\frac{1}{2}$

Mem. The agreement of the radius of the sphere with the focal length depends upon the quality of the glass.

In choosing concave glasses for remote objects beyond two or three hundred yards, the focal distance of the glasses should be the distance at which a small object appears distinct to the naked eye. For example: if the common type of a book is read distinctly without glasses at the distance of twelve inches, then the concave glasses required for seeing distinctly at the distance of two or three hundred yards, must have a focus of twelve inches. If distinct vision is required at the distance of twelve inches, and the distance at which a person reads with ease with the naked eye, be four inches, then by multiplying 12 by 4, and dividing by 12 minus 4, thus $\frac{12+4}{12-4} = \frac{48}{8} = 6$ inches, which is the focus required.

The eye pieces to common spectacles are generally oval, but sometimes circular. The oval glasses have an equal range of vision in a lateral direction, and are, of course, lighter than those of a circular form. There is occasionally an advantage in being able to look over them, but where an individual requires the same glasses for walking as he does for reading, the round ones may be preferred. Some persons suppose that round glasses must be ground more perfectly than those of an oval form, but in reality the latter are circular when they are ground, and subsequently clipped to the oval shape. In cases where spectacles are used for distant objects, the elasticity of the frames ought to be confined to the sides, and the front should be strong enough not to bend in the slightest degree, for if this point is not attended to, the glasses will lose their parallelism with the eyes; but for reading the case is different, and the front should yield a little, so as to throw the plane of each glass at right angles to the axis of vision for each eye.

A simple and convenient mode of ascertaining the focal length of spectacle glasses, is to fix a piece of white paper against the side of a room opposite to a window, and slowly to withdraw the lens from the paper till the images of the

most distant objects out of doors are distinctly seen upon it. The number of inches between the lens and the paper will be the focal length.

Another mode is to turn the lens with its axis pointing to the sun, and to withdraw it slowly from a piece of paper held at right angles to the axis of the lens: the point at which the sun's image is the smallest and brightest, is the focus, and the distance from this point to the lens, is the focal length of the glass. Of the same focal lengths, that glass which gives the smallest image or focus of light, is the best.

Cataract Glasses.

The object aimed at in operations for cataract, is either to extract the opaque crystalline lens from the eye; to cause its absorption; or to displace it so as to give a free passage to light. As the image formed on the retina depends upon the refractions produced by means of the crystalline lens and on its power of self adjustment to objects at different distances, the consequences of its loss usually are, indistinctness of vision and loss of power of accommodation to distance. If, prior to the formation of cataract, the eye was perfect (not merely as to its power to define objects at a

given distance, but as to the power of adjustment to distance also), there is after the operation an incapability of discerning near objects, as the eye no longer has the power to accommodate itself to the necessary focus.

To remedy these inconveniences double convex glasses are employed; * and it is necessary to have two pairs, of different focal lengths; one for looking at distant objects, the other for reading and writing.

There is considerable variety in the amount of assistance required, but glasses of four and a half inches focus ordinarily serve for viewing distant objects, and two and a half inches focus for writing or reading. In the selection of

* The lenses used by *divers*, if made of crown glass and equiconvex, must have the curvatures of both surfaces equal to that of the cornea, for in order that the refraction of such a lens may be equal to that of the cornea which it is intended to supply, the focal length of the lens in water, must be equal to that of the cornea in air.

It must be borne in mind that when the eye is immersed in water, the first and most considerable of its refractions is lost, for the refractive power of the aqueous humour is very nearly that of water, and so the cornea being bounded by surfaces which are nearly parallel, the rays will pass from water into the aqueous humour without undergoing refraction. Thus a powerful convex lens is required to afford distinct vision.

glasses, those of the *longest* focus that will answer the purpose, are to be preferred.

The glasses recommended by my lamented friend, the late Mr. Tyrrell, were of three quarters of an inch diameter, and mounted in a broad tortoise-shell rim, to diminish the weight of the spectacles, and limit the quantity of light admitted into the eye.

A cataract glass should, when placed in front of the eye, give perfect vision of objects at the distance at which they could be distinctly seen before the change in the lens commenced. If the focus is too long, the patient will find it necessary after a time to remove the glasses two or three inches from the eyes in order to see distinctly: in such a case glasses of a shorter focus must be procured. If the focus is too short, the patient will mistake the distance of objects from him, as they will appear nearer than they really are, and the hand, in the effort to grasp them, will fall short of them.

For some time after operation for cataract, the patient, (especially if young), should endeavour to do as much as possible without glasses, for although the adjusting power inherent in the eye is destroyed by the operation, nature will, if com-

pelled, make great efforts to provide a substitute. Mr. Middlemore observes,* "Some years ago I operated on a child four years old, and directed the little patient's friends not to employ glasses to assist his sight, without my permission: they carefully obeyed my directions, and this boy is not at the present time much more far-sighted than many persons whose lens has not been removed."

Sir W. Adams operated upon a postillion who was blind from cataract in both eyes. When the man resumed his employment he wore spectacles, not being able even to walk without them: finding, however, that travellers objected to be driven by a person requiring spectacles, he gradually left them off, and at the end of twelve months could drive and walk perfectly well without their aid.

Glasses, then, should not under any circumstances be permitted for a considerable time after the operation, nor indeed so long as vision continues to improve without them. If they be used too early, and the glasses are too powerful, the eyes may become enfeebled and require more

* A Treatise on the Diseases of the Eye. Vol. ii. p. 202.

and more assistance, so that after a time no lenses will be found of sufficient power. If the individual will wait until the eye has completely recovered, and will habituate the organ as much as possible to its altered state, he will then be in a condition to select glasses of a proper strength, and these if used sparingly, will probable serve him all his life.

CHAPTER V.

EFFECTS OF ARTIFICIAL LIGHT.

THERE are few people who have not, at one time or other, felt heat and irritation about their eyes after exposure to the glare and foul atmosphere of a brilliantly lighted and crowded room. These sensations, temporary perhaps while the exciting cause is occasional, often become permanent with the student who reads much by artificial light, and still more with those who do much fine work by gaslight in ill-ventilated rooms. The uncomfortable feelings arising from an injury thus inflicted upon the external tunic of the eye, though in themselves unpleasant and troublesome enough, are not unfrequently followed by others of a more formidable character. With this uncomfortable heat and dryness of the eyes there is not only the sensation as if particles of grit were in them, but the tears are hot and

scalding, and as the affection proceeds, a film renders objects indistinct, and gives to each light a coloured fringe. This effect is caused by a mucus of peculiar quality that is poured out, and carried by the action of the lids over the cornea. At the inner angle of the eye and at the roots of the eyelashes, an accumulation of thick yellow secretion takes place, and the lids are glued together upon the patient awaking in the morning, so that they are separated with difficulty: an unpleasant quivering of the lids often accompanies these symptoms, and is not the least annoying of them; and though a person thus suffering finds temporary relief from going into a dark room, yet the symptoms are again brought on by either reading, writing, or any other employment requiring close application by candle or gaslight.

If we examine a patient in this condition the first thing that will attract our attention will be the dull watery aspect of the globe of the eye, which has not its natural pure white colour. The edges of the eyelids are red, and the patient makes frequent efforts to avoid the glare of light by half closing them. Upon examining the inner surface of the lower lid, we find it to be of a bright red, and many vessels around the circum-

ference of the globe are manifestly in a state of congestion. The caruncle at the inner angle of the eye is also generally swollen and red. If examined by day when less irritated, the inner surface of the lower lid is marked with red patches, and between these patches are seen blood-vessels in a state of congestion. The papillæ of the lids are frequently somewhat enlarged, and it is a common thing to find small tumours in the lids, which give a purplish or yellow appearance to the corresponding point of the inner surface of the eyelid, and this point is generally surrounded by a cluster of vessels. The sclerotic coat has not that white hue which is natural to it, but is dull, and more vessels are visible upon it than appear in its healthy state. To this condition the term *Chronic Ophthalmia* has been applied. Should the eye be long subjected to its influence, the edges of the lids become thickened and in bad cases ulceration of their margins occurs, causing irregularity, if not entire loss of the eyelashes, and in very aggravated cases, more or less eversion of the eyelids.

It is important, by early and judicious measures, to arrest this disordered action before it has had time to produce effects so distressing and so unsightly.

There are, however, other affections of the eye

less offensive perhaps outwardly, but more serious in their consequences to the patient himself. Take the case of a hard reading student: after being engaged at his books for some time, a sort of mist comes over the sight, accompanied with a peculiar sensation in the eyes; the letters and words seem to run into one another, and the whole becomes indistinct. He ceases reading and covers the eyes with his hand: after a few seconds he finds that the mist has cleared away, and that he can again see distinctly. Persisting in his studies night after night, he finds the mist returns again and again, the intervals becoming shorter, and the attacks lasting longer, until at length it remains permanently. By-and-bye other symptoms appear: the patient is now annoyed by small black objects which he takes to be flies or smuts floating in the air, but after a time discovers that they are mere illusions. Now, and more especially during the darkness of night, he is startled by the appearance sometimes of flashes, at other times of sparks, coruscations, or perhaps of circles of light. He also feels a dull pain and sense of weight about the brow and forehead, extending occasionally down the side of the nose, and an uneasy fulness or aching towards the back of the eye. There is either sus-

ceptibility of the retina, so that a strong light causes pain; or the patient becomes conscious of less sensibility of that membrane, so that he does not see an object well except when it is strongly illuminated. As the disease advances, the muscæ volitantes become more numerous, and assume a variety of forms. At one time they appear as strings of beads, at other times as globules, and in some cases they take the permanent form of black spots of different sizes, so that an object actually appears smeared with Indian ink. These muscæ the student always finds most troublesome on a cloudy day and and after the eyes have been much used. In short, if the student keeps on his course unchecked, the symptoms will be daily aggravated, the retina will become the seat of serious disease, and amaurosis will be the result.

Besides literary men,—tailors, sempstresses, shoemakers, jewellers and watchmakers, are frequent subjects of impaired vision from overwork, and the symptoms are invariably aggravated by the depressing influence of poverty. Some idea of the frequent occurrence of this serious affection among the working classes may be formed from the fact, that between January, 1842, and January, 1846, no less than *three hundred and*

twenty-nine cases of this description were relieved at the North London Ophthalmic Institution alone.

The following cases, which I have selected from a large number, illustrate this affection.

Case XXII.—A gentleman engaged in literary pursuits consulted me in June, 1845. He stated, that for some time past he had been unable to pursue his studies by night, in consequence of a confusion of vision, which came on soon after he commenced reading or writing. A sort of thrill was felt in the eyes, and all objects immediately became indistinct before them:—at first, the act of winking removed this, but after a time he found it necessary to keep the eyes closed for a short period; and of late, the mist had become of such frequent occurrence, and caused so much annoyance, that he found it necessary to seek advice. It further appeared that he was extremely subject to muscæ volitantes, of which two in particular were persistent, but these, from long habit, he had ceased to regard. He had felt occasional dull pain about the brow, and a sensation of fulness in the eyes. Upon examination there was evident congestion of the vessels of the globe, and some irritability of the retina was apparent, as the

patient shrank from the exposure of the eyes to a moderate light. The pupils were contracted and sluggish in their movements. His general health had been good, and his habits temperate. By pursuing the plan of treatment which will be hereafter mentioned, this gentleman entirely recovered from the symptoms with the exception of the two persistent muscæ; these, however, did not cause him much inconvenience.

CASE XXIII.—Harriet Porter, a delicate looking female, aged nineteen, applied at the North London Ophthalmic Institution, Feb. 17, 1846. She was apprenticed to a milliner, and had been for some time in the habit of working with her needle for ten hours each day. During the London season, it was no uncommon thing, she stated, for her to work twelve, and even fourteen hours, daily. Her eyes, she said, felt strained, and ached, after sewing for a short time, and she experienced great difficulty in working, especially at night, in consequence of a mist which came over her sight, and rendered all objects indistinct. This mist had been gradually increasing, and of late she had seldom been free from it. She was subject to headache, and frequently experienced a sensation of weight over the brows, with aching of the eyes, muscæ volitantes

after the slightest exertion, and occasional flashes of light. The movements of the pupils were slow, the irides dull, and in the left eye I detected two minute adhesions of the margin of the pupil to the anterior capsule of the lens.

Rest to the eyes, an alterative course of mercury, in connexion with tonics, and continued counter-irritation to the forehead and temples, produced a highly beneficial effect; and the patient was discharged at the expiration of four months, greatly improved in health, and with her vision nearly perfectly restored.

Case XXIV.—In December, 1845, I saw a gentleman, thirty-five years of age, who gave me the following history of his case:—He was, by profession, a Solicitor, and two years previous to the above date, had been engaged in the superintendence of a complicated law-suit, which required the examination of a large number of ancient deeds and manuscripts, many of them almost illegible. Whilst engaged in the investigation of these documents he had frequently perceived muscæ volitantes, and had experienced confusion of vision, the lines and words running into each other. After a time he discovered that the sight of his right eye was impaired; objects were rendered indistinct by the appearance of a

gauze or network intervening before them, and a black spot was constantly present to that eye. He did not pay much attention to these symptoms, thinking that they would go away of themselves, but in this he was mistaken. The sight became worse and worse, letters appeared distorted, the flame of a candle was broken up and surrounded by a prismatic halo, ordinary print could no longer be discerned, and portions of words, and lines, disappeared, when he attempted to read large type. He was annoyed by a dull, heavy, pain in the forehead, extending round the head to the occiput, as if from the pressure of a tight cord. The sight of the left eye about this time became impaired, and the patient sought medical advice; but, with the exception of some doses of aperient medicine, and a lotion for the eyes, no particular treatment seems to have been adopted. When I saw the gentleman six months afterwards, vision was nearly extinct in the right eye; he could only make out a letter here and there of large type, and told me, that all objects seemed to be obscured by a thick, dark, grey cloud, occasionally illuminated by flashes of light; the frontal pain was a great source of annoyance, and he experienced, at times, considerable pain deep in the eye. With the left eye he

could still read ordinary print, but only for a short time, as the confusion of vision came on after the slightest exertion of the eyes.

Upon examination, the pupil of the right eye appeared dilated, of a muddy greenish hue, and insensible to the stimulus of light; the iris was dull and altered in colour; numerous purple vessels were visible upon the surface of the globe, and the sclerotica was of a leaden tint. The iris of the left eye was dull, the pupil inactive, and the same unhealthy condition of the external tunics was apparent, although in a less degree than in the right.

Blood was taken from the temples by cupping, the patient subjected to a mercurial course, counter-irritation employed for a long period, and the general health carefully attended to. The result was, that the mischief in the left eye was arrested, and useful vision restored; but disease had made too great progress in the right eye to admit of much benefit by remedial measures, although the pains in the head and the eye were subdued, and the health of the patient greatly improved.

The description given by Milton * of the symp-

* "My father," says Milton, "destined me, from a child,

toms and progress of this disease are very forcible. It occurs in an elegant letter, written in Latin, to his distinguished friend, Leonard Philaras, the Athenian. The following is a translation.

"*To Leonard Philaras, the Athenian.*

"I have always been devotedly attached to the literature of Greece, and particularly to that of your Athens; and have never ceased to cherish the persuasion, that that city would one day make me ample recompence for the warmth of my regard. The ancient genius of your renowned country has favoured the completion of my prophecy, in presenting me with your friendship and esteem. Though I was known to you only by my writings, and we were removed to such a distance from each other, you most courteously addressed me by letter; and when you unexpectedly came to London, and saw me, who could no longer see, my affliction, which

for the pursuits of polite learning, which I prosecuted with such eagerness, that, after I was twelve years old, I rarely retired to bed, from my lucubrations, till midnight. This was the first thing which proved pernicious to my eyes, to the natural weakness of which were added frequent headaches."

A second defence of the people of England, p. 384.

Milton's eyesight was much impaired when he undertook

causes none to regard me with greater admiration, and perhaps many even with feelings of contempt, excited your tenderest sympathy and concern. You would not suffer me to abandon the hope of recovering my sight, and informed me that you had an intimate friend at Paris, Dr. Thevenot, who was particularly celebrated in disorders of the eyes, whom you would consult about mine, if I would enable you to lay before him, the causes and symptoms of the complaint.

"I will do what you desire, lest I should seem to reject that aid which perhaps may be offered me by Heaven.

" It is now, I think, about ten years, since I perceived my vision to grow weak and dull; and at the same time I was troubled with pain in my kidneys and bowels, accompanied with flatulency. In the morning, if I began to read, as was my custom, my eyes instantly ached intensely, but were refreshed after a little corporeal exercise. The candle which I looked at, seemed, as it were, encircled with a rainbow. Not long after, the sight in the left part of the left eye (which I lost some years before the other) became quite ob-

his celebrated answer to Salmasius. During the progress of that work he became blind of one eye, and soon after its completion he lost the use of the other also.

scured, and prevented me from discerning any object on that side. The sight in my other eye has now been gradually and sensibly vanishing away for about three years; some months before it had entirely perished, though I stood motionless, every thing which I looked at seemed in motion to and fro. A stiff cloudy vapour seemed to have settled on my forehead and temples, which usually occasions a sort of somnolent pressure upon my eyes, and particularly from dinner till the evening; so that I often recollect what is said of the poet Phineas, in the Argonautics:—

> "'A stupor deep his cloudy temples bound,
> And when he walked, he seemed as whirling round,
> Or in a feeble trance he speechless lay.'

"I ought not to omit that, while I had my sight left, as soon as I lay down on my bed, and turned on either side, a flood of light used to gush from my closed eyelids. Then, as my sight became daily more impaired, the colours became more faint, and were emitted with a certain inward crackling sound; but at present, every species of illumination being, as it were, extinguished, there is diffused around me nothing but darkness, or darkness mingled and streaked with an ashy brown; yet the darkness in which I am perpetually immersed, seems always, both

by night and day, to approach nearer to white than black; and when the eye is rolling in its socket, it admits a little particle of light, as through a chink; and though your physician may kindle a small ray of hope, yet I make up my mind to the malady as quite incurable; and I often reflect, that as the wise man admonishes, days of darkness are destined to each of us. The darkness which I experience, less oppressive than that of the tomb, is, owing to the singular goodness of the Deity, passed amid the pursuits of literature and the cheering salutations of friendship. But if, as is written, man shall not live by bread alone, but by every word that proceedeth from the mouth of God, why may not any one acquiesce in the privation of his sight, when God has so amply furnished his mind and his conscience with eyes? While he so tenderly provides for me, while he so graciously leads me by the hand, and conducts me on the way, I will, since it is his pleasure, rather rejoice than repine at being blind. And my dear Philaras, whatever may be the event, I wish you adieu with no less courage and composure than if I had the eyes of a lynx.*

"*Westminster, September* 28, 1654."

* Appendix, D.

Treatment of Chronic Ophthalmia.—When opportunity is afforded of treating chronic ophthalmia in its early stage, but little difficulty is experienced in curing it; but when it has been neglected, and has given rise to disease of the Meibomian glands—to a general thickening of the lining membrane of the eyelids and the edges of the lids, and perhaps even, to destruction of the roots of the lashes, it is often exceedingly intractable.

In chronic ophthalmia then, should there be much redness of the inner surface of the lid, and an irritable condition of the eye, the local abstraction of blood will be desirable; the most convenient mode of obtaining this is by scarifying the congested vessels on the inner side of the lid; I prefer this to leeching the outer side of the lid, as ecchymosis is then apt to follow, which leaves a very unsightly appearance for some days. All that is required in the scarification, is to draw down the lid by stress upon its outer margin, and with a few light strokes of a sharp lancet to open the vessels which are most conspicuous; then to encourage the bleeding by warm fomentations.

Some persons recommend the application of leeches to the inner surface of the eyelid, but this is exceedingly objectionable on account of the

irritation which follows such a proceeding. Considerable benefit will be derived from the application of blisters to the temples or behind the ears. If placed upon the temples, care should be taken that they are not near the eyes, lest a puffy œdematous condition of the lids and cheeks should follow. The *acetum cantharidis* is very convenient for blisters behind the ears, or on the temples: it may be applied with a camel's hair brush, or a little lint; or blotting-paper may be soaked in it, and allowed to remain on the part. The blister may be conveniently kept open by a repetition of the application with the brush every second or third day.

The bowels should be opened by means of cooling purgatives, and the patient ought to abstain from fermented liquors, from reading or writing, and especially from using the eyes by artificial light.

Should the eyelids be glued together on awakening in the morning, the patient is not to attempt to open them by force, but is to soften the concretion by means of a little warm water, or warm milk and water. He will then be able, not only to separate the lids without difficulty, but also to remove such concretion without either pain or injury. If, instead of this, the patient

should attempt to open them by force, he will be sure to pull out some of the lashes, and thus will not only aggravate the inflammation at their roots, but will most probably injure, or even destroy, so much of the structure of the bulbs, as to arrest the lashes in their growth, and render them ever after, feeble, stunted, and irregular.

Ointments and collyria are powerful means of checking chronic inflammation of the lids and ulceration of the Meibomian glands. The *unguentum hydrargyri nitratis* of the London pharmacopœia, when modified as below, may almost be regarded as a specific.

No. 1.—℞. Unguent. Hydrarg. Nitratis ʒss. ad ʒj.

Adipis, ʒiiss.

Ol. Amygdalæ dulc. ʒj. Misce.

This preparation, well rubbed into the roots of the eyelashes at bedtime, will be found a most valuable remedy; but, to ensure its efficacy, all the concretion must be carefully removed, that the ointment may be brought fairly in contact with the ulcers, which, though generally minute, always exist at the roots of the lashes. The mere application of the ointment with a camel's hair pencil is not sufficient; it should be fairly rubbed into the outer edges of the eyelids with

the point of the finger, although without force or roughness. I have found the following preparations answer exceedingly well in several obstinate cases.

No. 2.—℞. Cupri Sulphatis pulv. ʒss.
Adipis, ʒiij.
Ol. Amygdalæ dulc. ʒj.
Misce.

No. 3.—℞. Zinci Sulphatis, pulv. ϑj.
Adipis, ʒiij.
Ol. Amygd., dulc. ʒj.—Misce.

It is desirable, occasionally, to change the ointment, for if the same is employed for some time, the parts become accustomed to its stimulus, and cease to be influenced by it. When much disease of the Meibomian glands exists, it is often highly desirable, after removing the crusts from the roots of the eyelashes, to touch the edges of the lids with nitrate of silver, or sulphate of copper, and then to use the ointment I have just named (No. 1.) The good results which follow the application of nitrate of silver, or sulphate of copper, are remarkable, and materially hasten the cure.

Of collyria there are a great variety: the following formulæ will be found to answer exceedingly well.

4.—℞. Acidi Acetici dilut.. ʒj. ad ʒij.
Vini Opii, ʒj. ad ʒij.
Aquæ distillatæ, fʒiiiss. Misce.

5.—℞. Zinci Sulphatis, gr. iv.
Aluminis Sulph., gr. vj.
Aquæ Rosarum, fʒ iv. Misce.

6.—℞. Zinci Oxydi, gr. xxx.
Misturæ Acaciæ, fʒiss.
Aquæ distillatæ, ʒij. Misce.

Formula No. 4 is exceedingly useful where there is much mucous secretion; in which case the eyes should be washed every morning with a very weak mixture of vinegar and warm water, (a tea spoonful to a pint,) which answers better than water alone. It is desirable to make an occasional alteration in collyria, as well as ointments; and in addition to the formulæ above mentioned, the *diacetate of lead*, in the proportion of two or four grains to the ounce of distilled water, affords a useful change.

Collyria may be used at night and the first thing in the morning, and either hot or cold, as is most agreeable. A convenient mode of warming a collyrium, is to place the bottle containing it into hot water. An eye-cup offers much facility in the application of a lotion to the eyeball, inasmuch, as by applying it half full to the open eye, and turning the head back, the lotion

gains access to the entire front of the eye; and more especially so, if the patient closes the lids several times. If an eye-cup cannot be procured, the eyes should be bathed with soft rag, dipped in the collyrium. Sponges are objectionable for such a purpose, because they contain particles of sand.

If an ointment has also to be used, the collyrium should be applied first, and the eyelids dried with a soft handkerchief, or with a linen rag, before the ointment is applied to them. As the ointment made with the Unguent. Hydrarg. Nitratis becomes hard, it should be softened before being used, at a candle.

Treatment of Impaired Vision. — Should there be reason to believe that the vision has become impaired by over-exertion of the eyes, and especially during the use of artificial light, it is of the highest importance that they should be allowed rest. Those pursuits should be abandoned, for a time at least, that have brought on the disease; unless this is done, the good effects of the remedies will be entirely counteracted. If (as is too often the case) the individual depends for subsistence upon the perfection of his eyesight, he should rest his eyes frequently, and pause whenever objects appear

confused, or his eyes feel fatigued, hot, and irritable. A temporary rest from his labours, and bathing the eyes with cold water, will not only afford much comfort, but be most salutary. He should work as little as possible by artificial light, for the light of day is much clearer, and defines objects so much better, that it should, upon all occasions, be preferred. It is, moreover, free from those heating, irritating, and noxious qualities, generally attendant on the use of artificial light. Ventilation also should be attended to. The custom of crowding work-people together in hot, close, and ill-ventilated apartments, is calculated to aggravate the mischief. A patient who was suffering from alarming symptoms of impaired vision, told me, that she was one of *seventy* women, who worked in one large apartment, lighted with gas, and constantly employed in making up black shawls and dresses; and that, out of the seventy, there were not ten who did not complain of either weakness of sight or pain in the eyes.

If the patient is young, and the symptoms marked, the wisest step would be to abandon the sedentary occupation, and try some pursuit which requires less exertion of the eyes; for it may be fairly concluded, from the symptoms commencing

early in life, that the patient cannot with impunity continue the occupation which has given rise to them.

If the symptoms of congestion of the retina are urgent, as evidenced by the frequency and brilliancy of the luminous spectra, by the intolerance of light, and by a deeply-seated aching pain in the eye, cupping from the temple will be desirable. Counter-irritation, by a blister on the forehead above the brow, has a great effect; and successive blisters, at intervals, will be found still more efficacious than one blister kept open by stimulating dressing. This system of counter-irritation may be continued for some time if found requisite; and the blisters should be applied, occasionally, over the supra-orbital foramen *—a rubefacient lotion, such as the one below, would be found serviceable.

℞.—Liquor. Ammoniæ fort. ℥ss.
Spirit. Rosmarini.
Spirit. Camphoræ, āā, ℥j.
Spirit. Vini Rectificati, ℥ss. Misce.

The above to be applied, by means of a piece

* A case has been recently mentioned to me of incipient amaurosis, that was cured by the application of a blister, ten inches long, placed lengthwise upon the spine, close to the head as possible.

of flannel, to the forehead, for two or three minutes at a time, every night, or every other night.

It is desirable to keep the bowels well regulated, and aloetic purgatives are the best for females in such cases.

An alterative course of mercury is a powerful means of arresting the progress of the disease in the retina. Two grains of hydrargyrum cum cretâ, with one grain of extract of hops, or of henbane, will be found safe, and may be given every night, or every night and morning, with advantage. Bichloride of mercury, when taken in minute doses of $\frac{1}{16}$ of a grain, three times a day, either in water, or combined with sarsaparilla, is very efficacious. The quantity of the bichloride may be gradually increased; and for feeble habits, gentian may take the place of sarsaparilla, with beneficial effect. When the complexion is pallid, the pulse feeble, the extremities cold, and other symptoms of general debility present themselves, a decidedly tonic plan of treatment, in combination with counter-irritation, will be advisable. The preparations of iron, and of bark, are in such cases invaluable. The tinctura ferri sesquichloridi, taken either in simple water, or in an infusion of quassia, two or three times a day,

(the dose being gradually increased from ten drops,) generally gives rise to marked improvement. The citrate of iron, and the citrate of quinine and iron, are also valuable preparations. The greatest attention must, however, be paid to the secretions, and the bowels regulated by aloes and myrrh, or by the compound decoction of aloes, either alone, or in combination with camphor mixture.

In cases of feeble stamina, cold ablutions followed by friction are attended with excellent effects. When the body is washed all over with a rough towel dipped in cold salt and water, then dried with another rough towel, and afterwards well rubbed with a horse-hair glove,* a delightful glow is felt, and the whole system is invigorated. Ablution is better performed with a towel than with a sponge, the exercise of rubbing and the roughness of the towel, preventing that unpleasant feeling of chilliness often complained of as attending the use of the sponge.

When there are weight and oppression about the head, the shower-bath is likely to be of much service, and especially if taken with the

* For delicate skins, the Kheesah or Indian flesh-glove, sold by Savory and Moore, 220, Regent-street, is an excellent substitute for the horse-hair glove.

feet in hot water. Several highly sensitive patients who could never bear the shock of a shower-bath while standing in a cold pan, have found their powers of endurance so much increased while standing with their feet in hot water, as to receive the shock not only with impunity but with the greatest benefit.

The regulation of diet is a matter of considerable importance. If there are indications of plethora, all stimuli must be forbidden, and a light farinaceous diet prescribed. If (as is the case in the majority of instances) there are symptoms of dyspepsia, such as fulness, uneasiness, and flatulence after meals; acidity, heartburn, and a foul tongue; a light nutritious diet will be advisable, consisting (if the patient is in circumstances to afford it) chiefly of tender mutton, poultry, or game, with stale bread, biscuit, or rice instead of vegetables: butter, fat, and indeed all greasy substances should be avoided. In many instances boiled cocoa nibs agree better than either tea or coffee. This preparation is free from the richness of ordinary cocoa or chocolate, and sits lightly upon the stomach; a breakfast of Scotch oatmeal porridge, properly prepared, agrees with some stomachs remarkably well, slightly increasing at the same time the

activity of the bowels. As drink, soda or Seltzer water, with a little brandy or genuine sherry, may be taken with the dinner when there is a tendency to acidity. With many persons the India pale ale agrees remarkably well: others prefer porter or stout. As a general rule, pastry, fruits, ices, and sweets of all kinds ought to be avoided. The chief meal should be taken about two o'clock, and the food thoroughly masticated. The custom of making a hasty breakfast at eight or nine o'clock, then fasting till six or seven, a period of ten hours, and after that eating a heavy meal when the system is in in a state of exhaustion, is more injurious to the digestive organs, and lays the foundation of a greater number of dyspeptic derangements than all other bad customs put together. If circumstances compel a man to dine late, let him take a sandwich, mutton chop, biscuit, or other light refreshment in the middle of the day.

Although it would be out of the power of the majority of the working classes to obtain such a diet as I have described, we may warn them against the evil consequences of indulgence in stimulating liquors, and lay down rules for their guidance in accordance with their means, and condition in life.

CHAPTER VI.

ARTIFICIAL LIGHT.

If the eyes are employed for a considerable period upon objects that are minute and highly illuminated by artificial light, the retina is very liable to be injured.

The injury may be trifling at first, and even transient; but if the exciting causes are prolonged, blindness, to a greater or less extent, as has been shown, will be the result.

I have already stated (chap. 1) that white light is a result of the due admixture of blue, yellow, and red rays. If certain proportions are not maintained, the light, instead of being white, will be tinged with that colour which is in excess. Mr. Field * has paid much attention to this subject, and has invented an instrument,

* Chromatography, by George Field, p. 37.

called the *metrochrome*, by which he has determined that the relative proportions in which the primary colours combine to form white light are,

Yellow . . 3 parts.
Red . . . 5 —
Blue . . . 8 —

These are called the primitive colours: the orange, green, violet, and indigo, being the effect of the varied combinations of red, yellow, and blue.

We have also seen that each of the seven primitive colours possesses a degree of refrangibility peculiar to itself, and that each colour has its undulations as regards number, size, and velocity, also peculiar to itself. But this is not all, for according to Sir H. Englefield, a thermometer exposed to the red rays stood at 72° Fahrenheit; whereas, when under the influence of the blue rays, the mercury sunk to 56°, which shows that each colour is attended by a degree of heat peculiar to itself.

We are conscious of the existence of light, and the phenomena of colours, by impressions made upon the retina: the delicate fibrillæ of which are acted upon by the vibrations of each ray.

Upon reference to the table (p. 10) it will be

seen, that the undulations of the red are fewest in number, and of course the greatest in length. Consequently they affect the retina the most forcibly.

Now artificial light having more red and yellow rays than daylight possesses, is the more likely to be fatiguing to the eyes.

It is a well-known fact, that when flame is not raised to a very high temperature, it gives out red light: at a higher temperature, the light is orange or yellow coloured; if the heat be still more increased, the blue rays are formed in greater abundance, and the light becomes much whiter. The blue rays, which are so necessary to neutralise the red and yellow rays, are not developed until the particles of carbon in the flame are more effectually brought into contact with oxygen. In flame produced from the combustion of tallow, oil, and coal gas, this is particularly the case, and if the particles of carbon are not sufficiently brought into contact with oxygen, the combustion is imperfect, and the flame smokes; that is, throws off a large quantity of soot.

"When in flames," says Dr. Ure, "pure gaseous matter is burnt, the light is extremely feeble. The density of a common flame is proportioned to the quantity of solid charcoal first

deposited and afterwards burned. The form of the flame is conical, because the greatest heat is in the centre of the explosive mixture. The heat diminishes towards the top of the flame, because in this part the quantity of oxygen is least. When the wick increases to a considerable size from the collecting charcoal, it cools the flame by radiation, and prevents a proper quantity of air from mixing with its central part. In consequence, the charcoal thrown off from the top of the flame is only red hot, and the greatest part of it escapes unconsumed."

When the eye is exposed to light in which the red and yellow rays prevail, the colours in excess produce first an excitement, and afterwards a degree of debility of the retina, precisely similar to the phenomena which have been already explained as following the use of blue or green glasses. Consequently, that light which approaches the nearest to white is best suited for the eyes, and that which partakes most of red, the worst.

Another cause of the injurious effects of artificial light is the direct and concentrated manner in which it acts upon the eyes. The rays from a candle or lamp fall direct upon the object which a person is regarding, (the page of a book

or sheet of writing paper for instance,) and are thence reflected into the eyes, carrying with them a considerable quantity of heat, which irritates and inflames the external coats of the eyes, and the lining membrane of the lids. A great portion of the heat which accompanies the sun's rays is absorbed by the repeated reflections from the atmosphere and clouds, or from the surface of the earth, which the light undergoes before it reaches the eyes.

Another cause of the distress produced by artificial light upon some eyes, is the fact of the rays not falling in parallel, but divergent lines upon the object, from which they are reflected in equally divergent lines; consequently, indistinctness of vision results from the want of definition of the object; whereas, the rays from the sun, owing to its immense distance from the earth, may be regarded as parallel.

The unsteadiness of artificial light is another serious evil to persons suffering from weak eyes. Every one must have experienced the discomfort and annoyance arising from the flickering of some candles, and have felt the relief afforded when they have been snuffed and made to burn steadily. One great superiority of daylight over artificial light is its perfect evenness. It is some

inequality, either in the current of air, or in the supply of combustible material, that renders the common flame unsteady and wavering.

Carbonic acid gas is one of the chief products of combustion, and when in excess in the air we breathe, is prejudicial to the human system ; where so far diluted with air as to admit of its being received into the lungs, it operates as a narcotic, producing drowsiness, difficulty of breathing, pain in the head, giddiness, and faintness. But carbonic acid gas is given out in respiration also ; for respiration is a slow combustion, and presence of the gas in undue quantity is the cause of the headache so often felt when in a crowded, ill ventilated, and brilliantly lighted room.

Carbonic acid gas, and the vapour of water, (the products of the oxygenation of the carbon, and the evolution of hydrogen during combustion,) accumulate to a great extent in crowded apartments, not properly ventilated, and especially so when the lights are numerous.

The effects upon the human system are very serious, leading to impairment of health, principally through the medium of the brain and nervous system. This gas has neither colour nor smell, and a person may be exposed to its pernicious influence for some time uncon-

sciously, and even at last is only made aware of its presence by its effects. The air in rooms artificially illuminated may have other sources of contamination; if, for example, the tallow of the candles has been hardened by admixture with arsenic, or the gas has not been purified from sulphurous compounds, the fumes arising from the combustion of the arsenic and of the sulphur, materially increase its deleterious character. The effects upon the human frame are shown occasionally in chlorine manufactories, where the workmen, from an accidental exposure to a stream of pure chlorine gas, sometimes fall down suddenly, as if they had been shot; and even in manufactories of sal ammoniac, the men employed endure the most severe convulsions, when exposed, as they are occasionally, to the influence of sulphuretted hydrogen gas.

As a knowledge of the different kinds of artificial light and their comparative merit, is desirable, I propose to add a few remarks upon those principally employed, and to suggest some means of obviating their injurious effects.

The artificial light in most extensive use at the present day, is that arising from the combustion of carburetted hydrogen gas, a gas produced from the destructive distillation of common coal.

For general purposes this answers effectually, although it is open to the objection of evolving a large quantity of heat and carbonic acid gas. The ordinary gas burners are not well adapted for reading, writing, sewing, drawing, or similar employments which require a light of considerable defining power and pure colour. The colour of a common gas-light is yellow, and to define minute objects, it is necessary for it to be placed near the eyes, which are liable to be injured by its heating properties as well as its impure colour. Gas-lights differ from most other lights in their extreme tenacity of combustion; they will burn for a considerable time in air so loaded with carbonic acid, moisture, and nitrogen, as to extinguish oil lamps and candles. There is generally also some escape of unconsumed gas, so that special arrangements ought to be made for the ventilation of rooms lighted with gas.

The principal kinds of gas burners in use are, 1. The *Cockspur jet*, in which the gas issues from a small hole in a steel nozzle. 2. The *Batswing*, a thin sheet of gas produced by its passing through a fine saw-cut made in the upper part of a hollow globe. 3. The *Fish-tail jet*, in which two jets of gas meet each other at an acute angle, and spread each other out in a thin film

of gas at right angles to the line in which the two jets are. The flame has the form of a thin triangular sheet or fish-tail with the narrow end downwards. 4. The *Argand,* in which the gas issues from a number of small jets arranged in a circle: when lighted, all the jets unite, forming a tube of flame; a chimney being then applied, and equable currents of air established on each side of the flame, great facility is afforded to the union of the oxygen of the atmosphere with the carbon of the gas. 5. The *Fan,* is a spreading semicircle of small and separate jets.

The Argand, if properly attended to, excels all others in brightness and steadiness of flame.

Every burner has just one quantity of gas that suits it best, or in other words, is the most economical; offording a greater amount of light, with less smoke, than any other quantity with which it can be supplied.

The Camphine lamp has obtained much celebrity of late on account of the purity of its flame and its strong illuminating powers. It is admirably adapted, if the camphine be good and the lamp well managed, for lighting apartments; but care should be taken in using it for reading, not to have it too near the book, or it will be found that after the employment of the

camphine lamp, ordinary candlelight becomes insufficient. A literary gentleman informed me, that formerly two wax candles afforded him quite sufficient light for reading, but that since he had used the camphine, their light was too feeble for that purpose. By using for a time a light more intense than that ordinarily employed, and then returning to the latter, it ceases to excite the retina sufficiently; in the same way as by increasing the power of spectacles too rapidly, the more moderate powers become useless. By the injudicious employment of too brilliant light, for the purpose of study, the sensibility of the retina may be blunted by slow and scarcely perceptible degrees, without the patient being alarmed by any sudden impairment of vision, or marked difference in his sight.

Mr. Smee recommends naphthalised coal gas as affording a very superior light. It is the ordinary gas passed through an apparatus containing a series of sponges saturated with coal tar naptha, and that gentleman advises that it should be burned, either by means of a "Scotch fish-tail burner," or else by an argand, in order that a good supply of oxygen may be obtained, which is as indispensable for the production of a brilliant light, as for the prevention of smoke.

The light obtained by burning oil is of a superior description, but much depends upon the construction of the lamp. The argand burner is the best for oil as well as for gas, inasmuch as the flame is cylindrical; it is by far the best supplied with the oxygen of the atmosphere, which by causing a more perfect combustion, materially increases the brilliancy of the flame. An improvement upon the ordinary argand oil-lamp is the "Hot-oil" lamp, in which the oil is heated, and rendered sufficiently fluid to be raised by the capillary attraction of the wick without that tendency to clog which is an objection to common oil-lamps.

In the *Solar* lamp, air instead of being permitted to ascend in the usual manner around a flame, is directed against that part of the flame where it is most important to have a sufficient and regulated supply.

Before dismissing the subject of lamps, I may mention that Sir David Brewster has invented a lamp which affords an homogeneous yellow light, valuable in microscopical observations as preventing chromatic aberration. The term *monochromatic* has been applied to it. It consists of a spirit-lamp whose wick has been soaked in strong brine, and the flame is allowed to play on

a mass of common salt placed above it; under its influence the brilliant red of vermilion appears pale yellow. Cochineal assumes a black hue, as does the bright blue of ultramarine and cobalt.

The light afforded by *wax* candles is remarkably pure and agreeable to the eyes. It is sufficient for the purpose of illumination without inducing fatigue of the organs. Its defining powers are considerable, whilst it is devoid of the glare and heating properties which render gas so objectionable. Common candles emit a very inferior light, and the flickering, unevenness, and want of steadiness of the flame constitute an objection from which even those made of wax are not quite free, but which is particularly conspicuous in the commoner descriptions of candles. Upon the whole, a person who employs his eyes much by night, cannot do better than use wax candles. I find from experience that the light they afford enables me to write longer with less distress to the eyes, less irritation of the lids, and a greater amount of general comfort than any other.

The best *composition* candles are made of stearine mixed with one-fourth or one-eighth of its weight of wax. They afford an excellent light, and are less expensive than wax.

The injurious effects of artificial light shown to arise from its having an excess of red and

yellow rays, may be obviated by surrounding the light with a shade, coloured blue on the inner surface. The blue rays reflected from the shade mingle with the reddish yellow rays proceeding directly from the flame, and produce a light of a much purer and whiter colour: this may be effected by painting the inner surface of the shade with cobalt blue, applied evenly.

Another mode of improving artificial light is by surrounding the lamp with a glass chimney tinged with a very pale blue; this absorbs the excess of red and yellow rays, and renders the light more agreeable.

A third means of absorbing the red and yellow rays, is by causing the light to pass through a fluid coloured blue. Wood engravers are in the habit of employing a glass globe of about six inches diameter filled with water, which being interposed between the light and their work, converges the rays and thus increases the illuminating power. If a very small quantity of ammoniuret of copper is added to the water, it assumes a delicate blue colour, and renders the light transmitted through it purer by absorbing a portion of the red and yellow rays. The water should be of such a tint that a piece of white paper held behind the bottle by daylight appears sky blue.

Condensers, such as are here described, have another advantage; that of diminishing the heating powers of the rays, for Professor Melloni has shown, that when rays of artificial light are passed through a thin stratum of water, their heating power is diminished eighty-nine per cent. It is an interesting fact that though the heat of the sun-light will pass through transparent media, that of a candle will not, so long as such media are cold.

Persons working in rooms heated with hot air, should place (as is done on the continent) in some convenient situation, a flat dish containing water, which by its exhalations will render the air less arid; and those engaged in work requiring a strong light will find that one or two large wet sponges set near them, will cool and moisten the surrounding air in the same manner.

Silken shades suspended from the forehead are extensively worn, and afford comfort by excluding a portion of the light; but they tend to keep the eyes too hot, unless means are taken to cool the upper surface of the shade by damping it. It is to be preferred, when it can be accomplished, to have the shade around the light.

Blue spectacles are sometimes used, but, independent of the objections to them before

stated, they soon become hot and uncomfortable in consequence of the rays absorbed by them from their want of perfect transparency: if neutral tint glasses are made use of, this evil may be obviated by having two pair, and using them alternately.

A simple and convenient shade may be made of cartridge paper cut into the shape indicated in Fig. 18.

Fig. 18.

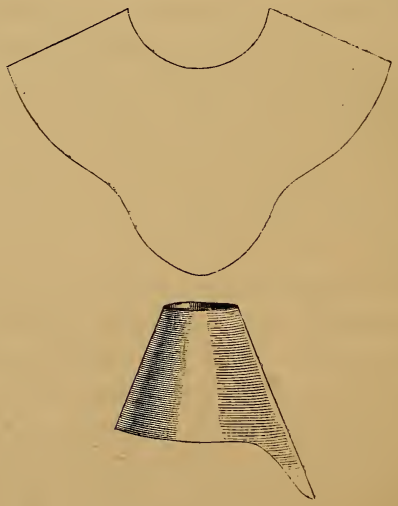

Fig. 19.

When the straight edges are united, a conical shade is formed, with a tail-piece to it, as in Fig. 19.

This shade fits over any ordinary reading lamp, and is to be placed so that the tail-piece shall be between the eyes and the candle. It may be coloured on the inside with a solution of cobalt blue, and the outside should be tinged with a weaker solution of the same to give it a grey tinge. It is important that the inner surface be free from gloss, and when a metallic shade is used, the inside should be painted a faint blue, but "dead," that is to say, free from polish. It should have pieces of tin attached to the margins as in Fig. 20, and placed between the eyes and the flame of the lamp in order that those organs may be completely protected from the glare and heat.

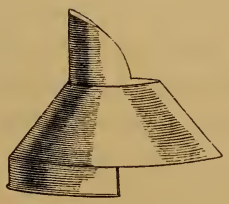

Fig. 20.

The comfort afforded to weak eyes by this simple contrivance is very great.

Shades of ground glass are well adapted for purposes of general illumination, as they soften the light and diffuse it by presenting a great number of luminous points. They are not, however, so well adapted for reading lamps, an opaque shade being preferable.

Carbonic acid gas, as already stated, is a powerful narcotic, and is at the same time the common product of combustion and of respiration. If, therefore, many persons are employed in a close room where numerous lights are burning, the amount of carbonic acid so produced must of necessity be found highly deleterious; inasmuch as the quantity produced is in a ratio to the crowded state of the room, and the number of lights burnt.

Dr. Arnott states that "in respiration a man draws into his chest at one time, about twenty cubic inches of air, and of that air a fifth part is oxygen, of which again there is converted into carbonic acid gas nearly one half. About fifteen inspirations are made in the minute, vitiating, therefore, three hundred cubic inches, or nearly one sixth of a cubic foot of atmospheric air; but which, mixing as it escapes with several

times as much pure air, renders unfit for respiration, under ordinary circumstances, at least two cubic feet of air every minute.

Tredgold calculates that the air directly vitiated amounts to eight hundred cubic inches per minute. He also computes that it requires three cubic feet of air per minute to carry away the insensible perspiration of the skin.

Taking these results, and the quantity of air vitiated by combustion, he calculates that when a room containing several persons is lighted to the customary degree, it will be necessary to supply four times as many cubic feet of fresh air per minute, as there are persons in the room.

Carbonic acid gas where pure and of equal temperature is heavier than common air, but the carbonic acid gas of respired air is warmer than common air, besides being combined with nitrogen and the vapour of water, both of which also are lighter that common air ; so that respired air, though containing carbonic acid gas, is really lighter than common air and rises to the ceiling ; and as fast as it escapes by openings in the ceiling, fresh air rushes into the room under doors, and through any apertures which may exist near the ground.

In rooms thus ventilated, the carbonic acid is

carried away and can exercise no pernicious influence upon the human frame; but in crowded, low, ill-ventilated apartments, this impure air accumulates to a great degree, and gives rise to headache, oppression of breathing, giddiness and indistinct vision, and eventually produces a serious effect upon the health. For instance, in its more aggravated form it not only induces apoplexy and consumption, but decidedly favours that depression which leads to habitual lowness of spirits and even to suicide. So that bad ventilation may fairly be said to be injurious to the mind, as well as the body.

Perhaps no class of men suffer more severely from the evil effects of impure air than tailors. They generally work in crowded rooms, strongly illuminated, and where from an utter neglect of ventilation the heat is excessive, and the atmosphere most vitiated. Dr. Southwood Smith draws the following vivid picture of their condition. "In a room (says he) sixteen or eighteen yards long and seven or eight wide, eighty men worked together; they were close together, nearly knee to knee; in summer-time the heat of the men, and the heat of the irons made the room twenty or thirty degrees higher than the heat outside. The heat was then most suffocating,

especially after the candles were lighted: such has been the state of the atmosphere, that in the very coldest nights, large thick tallow candles have melted and fallen over from the heat. This state of the place of work produced a very depressing effect on the energies of the workmen; many could not stay out the hours, and went away earlier. Those who were not accustomed to the place generally lost appetite. The natural effect of the depression was, that recourse was had to drink as a stimulus, gin being taken instead of food."

In printing houses, even with low ceilings, there is often an immoderate use of gas, and no means of obtaining heat, except from the gas lamps and products of combustion.

I have stated these facts somewhat at length, because the impaired vision so distressingly common amongst tailors and printers, may be attributed quite as much to the unfavourable condition in which they work as to the unavoidable strain upon the eyes.

The pernicious effects of gas-lights may partly be obviated by preventing the vitiated air mingling with the air of the apartment. Let a tube be attached to the burner which shall convey the products of combustion completely away. There

are two modes; either by an upward movement, or by a downward movement. Professor Faraday's ventilator is as nearly perfect as possible. The following is a representation of it.

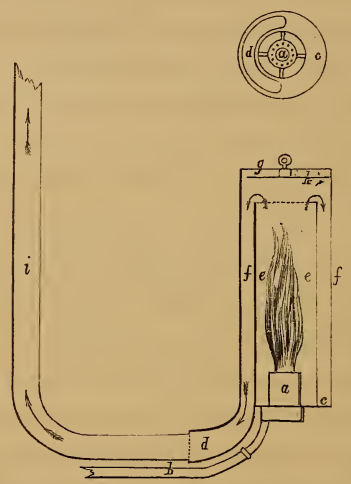

Fig. 21.*

* *a* is the burner; *b* the gas-pipe leading to the burner; *c* the glass holder, with an aperture in it opening into the mouth *d*, which is attached to the metal chimney *i*; *e* is the ordinary glass chimney; *f* an outer cylinder of glass, closed at the top by plates of mica, *g h*.

The upper sketch is a plan of the glass holder showing the burner *a* in the centre, perforated with jets, with opening

The gas-light has a glass chimney as usual, but the glass-holder is so constructed as to sustain not merely the chimney, but an outer cylinder of glass larger than the first. The glass-holder has an aperture in it connected by a mouth-piece with a metal tube, which serves as a ventilating flue, and which after passing horizontally to the centre of the chandelier, there ascends to produce draught, and carry off the foul air. The tube may be conducted into a chimney, or through a wall, if a single light is burnt. The arrows in the sketch indicate the course of the foul air, which is thus carried away.

A plan devised by P. C. de la Garde, Esq., has been adopted at the Devon and Exeter Institution, and it is said to be attended with great success.

A tube, an inch in diameter, having a trumpet-mouth, is suspended immediately over the flame of an argand burner. The upper part of this tube enters for about twelve inches into a tube of similar shape, but of double the diameter.

round it to allow of a free admission of air to the flame ; and the aperture *d*, which communicates with the metal chimney *i*.

The apparatus is to be procured of Mr. R. Faraday, 114, Wardour Street, Soho.

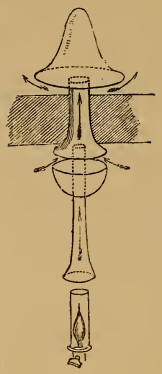

Fig. 22.

The lip of the trumpet-mouth of the larger tube is exactly level with the ceiling; the upper end passing through the roof is protected from rain by a conical cap. The column of hot air ascending rapidly the glass chimney, passes through the small tube with great velocity into the larger tube, through which it also occasions an ascending current; whilst the air vitiated by combustion escapes, the larger tube permits an escape through the roof not only of the air which is received from the smaller tube, but also of the air vitiated by respiration or other cause, and

collected in the upper part of the room. All moisture condensed in the upper tube during cold weather is caught in a vessel which surrounds the tube, immediately below the mouth of the upper one. The entire apparatus is of copper, and for seven years has required neither cleaning nor repairing.

APPENDIX.

Appendix A.

The inability to distinguish certain colours is probably much more common than is generally supposed. Unless it exists in a marked degree the person is hardly conscious of it. This interesting subject has been fully discussed by Professor Wartman, in an elaborate paper which is to be found in the fourth vol. of Taylor's Scientific Memoirs. The Professor divides the affection into *Dichromatic Daltonism*,* and *Polychromatic Daltonism*. The former may be illustrated by the following cases : Dr. Tubervile has recorded a case of a young woman who could appreciate white and black only, and yet had the ability to read with very little light.†

* It is much to be regretted that such a word should have been invented. It is only used here in reference to the paper in question.

† Phil. Trans. No. 164, p. 736.

Mr. Huddart, in a letter to Dr. Priestley,* mentions a shoemaker who called all bright tints white, and all dull tints black; and Dr. Spurzheim† mentions a family that could distinguish black and white only.

This aggravated form of "colour blindness," is however less common than the *polychromatic*, of which the following are examples.

Dr. Dalton could distinguish in the solar spectrum only yellow, blue, and purple. By day, rose colour appeared skyblue, crimson a dirty blue, red and grass green were identical. Dr. Whewell relates, that having asked Dalton to what object he should compare the scarlet robe he wore as doctor, he pointed to the trees, and declared that he could see no difference between them.

A gentleman of my acquaintance stated to me that if a stick of red sealing-wax was to be laid upon a grass plot, he would not be able to distinguish the slightest difference between the colours.

Mr. Troughton could distinguish no colours but blue and yellow, and Mr. Harvey‡ mentions

* Phil. Trans. Vol. lxvii. p. 260.

† Phrenology, 3rd. Ed. p. 276.

‡ Edin. Phil. Trans. vol. x. p. 253.

a tailor who perceived no other colours in the spectrum but yellow and light blue, and on one occasion was found patching a pair of black silk breeches with a piece of scarlet silk.

Dr. Priestly speaks of an artist whose companions have by putting his colours out of the order in which he kept them, sometimes made him give a gentleman a green beard, and adorn a beautiful young lady with a pair of blue cheeks.

A gentleman examined at my request a number of skeins of variously coloured worsted, with the following result. He could discern no difference between blue and lilac, but arranged two shades of blue and three of lilac together, as five shades of blue. Dark green and dark red appeared to him as one colour, which he called brown. Yellow and pink he recognised. Scarlet and bright green he thought the same; and he stated to me that he never could discover the slightest difference of hue between the flowers of the scarlet geranium and the green leaf.

Dr. Dalton was of opinion that the humours of his eyes were coloured blue, and so absorbed a great proportion of the red and other least refrangible rays; but after his decease his eyes were carefully examined by Sir David

Brewster, who could not discover any abnormal or unusual condition in any part. The vitreous and aqueous humours were perfectly free from colour.

Various explanations have been offered to account for the insensibility of certain eyes to colours, but that which is open to fewest objections has been proposed by Sir John Herschel, who attributes it to a defect in the sensorium itself: Sir John carefully investigated the case of Mr. Troughton, and instituted a series of ingenious experiments for the purpose of ascertaining, if possible, the cause of the imperfection. That distinguished philosopher satisfied himself "that all the prismatic rays have the power of exciting and affecting the eyes with the sensation of light, and producing distinct vision, so that the defect arises from no insensibility of the retina to rays of any particular refrangibility, nor to any colouring matter in the humours of the eyes preventing certain rays from reaching the retina, but from a defect in the sensorium by which it is rendered incapable of appreciating exactly those differences between rays on which their colour depends." *

* Encyclop. Metrop. Article "Light."

Professor Wartmann recommends, as an easy means of rectifying to a certain extent the error of appellation of colour, the examination of coloured objects through a transparent medium, as glass of a certain known tint; suppose this tint to be red, and suppose the impression of a green and a red body, to be the same to the naked eye, they will manifestly become distinguished by the use of the transparent screen. This method, however ingenious, only remedies mistakes in the specific nature of colours, and would not detect those which apply to the shades of the same tint. The chief facts which Professor Wartman seeks to establish are—

That many more persons are subject to it than is generally supposed, and that there are considerable varieties as to its extent.

That the female sex furnish few instances, and that it does not always date from the birth.

That the subjects of this affection do not judge of complementary colours as others do.

That many of them are not sensible to the least refrangible rays. That they are sensible of the lines in the spectrum discovered by Fraünhofer.

And, lastly, that, as Sir John Herschel thinks, the phenomena does not arise from any peculiar

conformation of the eyes, but has its origin in a defect of the sensorium.

Appendix B.

With reference to the effects of the non-luminous rays upon the eye, Mr. Paget states,* "To determine why the chemical and calorific rays do not produce on the eye the sensation of light, and to determine whether the retina is insensible to them, or they are hindered from reaching it, Ernst Brücke has instituted some simple and very interesting experiments. The colour obtained from Guaiacum wood is changed to a dark bluish green on exposure to diffused light, the change being effected by the chemical rays—those beyond and just within the violet; but if part of a surface tinged with the original colour be so screened that the light can pass to it, only through an ox's or other animal's lens, the colour of this part is hardly changed. A part similarly screened, but having light admitted to it through a cornea, is only a little

* British and Foreign Med. Rev. No. xliii. p. 287.

more changed; by light admitted through a vitreous humour yet a little more; and if to this screened part the light be made to pass through both a cornea, and a lens, then, while all the rest of the surface undergoes the usual complete change of colour, this remains often unchanged, and is at most changed only in the slightest degree, so that it appears that the transparent parts of the eye absorb the chemical rays of light before they can reach the retina, and that, therefore, they are invisible."

Sir John Herschel, in his admirable article on Light in the Encyclopædia Metropolitana, observes, "Although any kind of impulse, or motion, regulated by any law, may be transferred from molecule to molecule in an elastic medium; yet in the theory of light, it is supposed that only such primary impulses as recur according to regular periodical laws, at equal intervals of time, and repeated many times in succession, can affect our organs with the sensation of light. To put in motion the molecules of the nerves of our retina with sufficient efficacy, it is necessary that the almost infinitely minute impulse of the adjacent ethereal molecules should be often and regularly repeated, so as to multiply, and as it were concentrate their effect. Thus, as a great

pendulum may be set in swing by a very minute force often applied, at intervals exactly equal to its time of oscillation; even so we may conceive the gross fibres of the nerves of the retina to be thrown into motion by the continual repetition of the ethereal pulses: and such only will be thus agitated, as from their size, shape, or elasticity, are susceptible of vibrating in times exactly equal to those at which the impulses are repeated. Thus it is easy to see how the limits of visible colour may be established; for if there be no nervous fibres in unison with vibrations more or less frequent within certain limits, such vibrations, though they may reach the retina, will produce no sensation. Thus, too, a single impulse, or an irregularly repeated one, produces no light, and thus also may the vibrations excited in the retina continue a sensible time after the exciting cause has ceased, prolonging the sensation of light (especially if a vivid one) for an instant in the eye, in the manner described. We may thus conceive the possibility of other animals, such as insects, incapable of being affected with any of our colours, and receiving their whole stock of luminous impressions from a class of vibrations altogether beyond our limits."

A difference of opinion exists as to the mode in which the *adjustment to distance* is produced. I believe it to be effected by the ciliary processes: and one reason which leads me to this opinion is, the curious mechanism found in the eyes of birds: In them, there is a plicated fold of vascular membrane analogous in structure to the choroid, and blackened by the pigmentum, lodged like a wedge in the substance of the vitreous humour; it is called "marsupium" or "pecten," and is attached behind to the termination of the optic nerve; in many birds it is connected with the posterior part of the capsule of the crystalline. Concerning its use Professor Owen says—*

"We are inclined to consider the marsupium as an erectile organ adapted to receive a varying quantity of blood, and to occupy a variable space in the vitreous humour; when fully injected, therefore, it will tend to push forward the lens either directly or through the medium of the vitreous humour, which must be displaced in a degree corresponding to the increased size of the marsupium; the contrary effects will ensue when the vascular action is diminished."

* Cyclopedia of Anatomy and Physiology, Art. Aves. p. 305.

The ciliary processes in the human subject (as exhibited in the beautiful preparations of my friend Mr. John Quekett) present a wonderful complexity of vascular organization, and appear admirably adapted for altering the position and possibly the form, of the crystalline lens, according as they are turgid with blood, or comparatively empty; a change in the structure of the vessels, and increased rigidity of the crystalline lens, may account for the loss of adjusting power in age.

The great alteration which must take place in the eyes of birds to enable them to see at vast distances, or quite near, requires a corresponding provision: it is thus described by Professor Owen:* "The cornea possesses the same structure as in mammalia, but differs with respect to form. When the posterior part of the eye is compressed by the muscles, the humours are urged forwards and distend the cornea; which at that time becomes much more prominent in most birds than it is ever observed in mammalia; and under such circumstances the eye is in a state for perceiving near objects. When the muscles are quite relaxed, the contents of the eye-ball retire to the posterior part, and the

* Op. citat. p. 304.

cornea becomes flat or even depressed: this is the condition in which we always find the eye of a dead bird, but we can have no opportunity of perceiving it during life: it is only practised for the purpose of rendering objects visible at an extreme distance."

Appendix C.

To prevent snow-blindness, the Tartars and Persians wear a sort of network before their eyes, made of black horsehair. The Greenlanders and Esquimaux construct snow spectacles, or *snow eyes,* as they call them, for the same purpose: they are made of a very smooth wood, like poplar: the posterior surface is deeply excavated to prevent its obstructing the free motion of the eyelids. On each side, a notch is cut at the lower margin to allow a free passage for the tears. The upper margin of the front surface is more prominent than the under, to act as a shade to the eyes. The inner surface is blackened with soot, to absorb a portion of the dazzling light. The openings for vision are horizontal and narrow slits, one placed before each eye, the lids being nearly closed. By this contrivance the eyes are not merely protected from the dazzling effect of

the snow, but distant objects are rendered more distinct.

The effects produced upon the eyes by the glare from snow is graphically described by a sufferer, Jacques Balmat, who was the first to ascend Mont Blanc. Dr. Paccard was the companion of his adventurous exploit, and both underwent great hardships in the journey. Balmat says,* "By the time I had reached the grand plateau, my eyes were so dazzled by the snow that I was nearly blind: now, we always provide ourselves with green veils for those expeditions, but at that period we were ignorant of their use. As I could not see to advance—for whichever way I looked I saw nothing but large drops of blood—I sat down and closed my eyes: in about half an hour, when I opened them, my sight was so far restored that I could venture to move forward." These two adventurous men struggled on and succeeded in affecting their purpose, but had to pass the night in the snow: Balmat thus continues,—"About six o'clock the next morning the Doctor (Paccard) woke me. 'Balmat,' said he, 'it's very odd—I hear the birds singing, and it's quite dark!' 'Dark!' said

* Abridged from Chambers' Edinburgh Journal.

I, 'open your eyes and look about, its broad daylight.' 'I don't think I can open them,' said he, 'I can see nothing.' I looked at him—his eyes were as wide open as he could stare—he was perfectly blind: however, I got him down hill and took him to his home."

It is satisfactory to know that the Doctor eventually recovered his sight, but Balmat himself could only see in the twilight, for a long time afterwards.

A case is mentioned by Mr. Lawrence,* of a gentleman who had gone out shooting at night, the ground being covered with snow; the next day his sight was dull—it became very imperfect, and continued so in spite of a variety of treatment.

The following account is given by an eye-witness. "When the division of Cordova marched from Cuzco to Puno there was a very heavy fall of snow. They continued their march the next morning. The effects of the rays of the sun reflected from the snow upon the eyes produces a disease which the Peruvians call *norumpi*. It occasions blindness, accompanied by excruciating tortures. A pimple forms in the eye-ball, and

* A Treatise on the Diseases of the Eye, p. 511.

causes an itching pricking pain, as though needles were continually piercing it. The temporary loss of sight is occasioned by the impossibility of opening the eyes for a single moment, the smallest ray of light being absolutely insupportable. The only relief is a poultice of snow, but as that melts away, the intolerable tortures return. With the exception of twenty men, and the guides, who knew how to guard against the calamity, the whole division were struck blind with the *norumpi*, three leagues distant from the nearest human habitation. The guides galloped on to a village in advance, and brought one hundred Indians, to assist in leading the men. Many of the sufferers, maddened by pain, had strayed away from the column, and perished before the return of the guides, who, together with the Indians, took charge of long files of the poor sightless soldiers, clinging to each other with agonised and desperate grasp. During their dreary march by a rugged mountain path, several fell down precipices, and were never heard of more. Out of three thousand men, Cordova lost above one hundred."*

* Memoir of General Miller.—Edinburgh Phil. Journal, vol. 18.

The following interesting experiments made by Sir Isaac Newton, and communicated by him in a letter to Mr. Locke, (June 30th, 1691,) were first given to the world in 1830.

" The observation you mention in Mr. Boyle's Book of Colours, I once made upon myself with the hazard of my eyes. The manner was this. I looked a very little while upon the sun in the looking glass, with my right eye, and then turned my eyes into a dark corner of my chamber, and winked, to observe the impression made, and the circles of colours which encompassed it; and how they decayed by degrees, and at last vanished. This I repeated a second and a third time. The third time, when the phantasm of light and colours about it were almost banished, intending my fancy upon them, to see their last appearance, I found to my amazement that they began to return, and by little and little to become as lively and vivid as when I had newly looked upon the sun; but when I ceased to intend my fancy upon them they vanished again. After this, I found that as often as I went into the dark, and intended my mind upon them, (as when a man looks earnestly to see a thing which is difficult to be seen,) I could make the phantasm return without looking any more upon the sun: and the

oftener I made it return, the more easily I could make it return again; and at length, by repeating this without looking any more upon the sun, I made such an impression on my eye, that if I looked upon the clouds, or book, or any bright object, I saw before it a round bright spot of light, like the sun; and, which is still stranger, though I looked upon the sun with my right eye only, and not with my left, yet my fancy began to make an impression upon my left eye as well as upon my right. For if I shut my right eye, or looked upon a book or a cloud with my left eye, I could see the spectrum of the same almost as plain as without my right eye, if I did but intend my fancy a little while upon it: for at first, if I shut my right eye and looked with my left, the spectrum of the sun did not appear till I intended my fancy upon it, but by repeating this, it appeared every time more easily. And now, in a few hours time, I had brought my eyes to such a pass, that I could look upon no bright object with either eye, but I saw the sun before me, so that I durst neither write nor read: but to recover the use of my eyes, shut myself up in my chamber made dark, for three days together, and used all means to direct my imagination from the sun; for if I thought upon him, I presently

saw his picture though I was in the dark. But by keeping in the dark, and employing my mind upon other things, I began in three or four days to have some use of my eyes again, and by forbearing to look upon bright objects, recovered them pretty well, though not so well but that for some months after, the spectrum of the sun began to return as often as I began to meditate on the phenomena, even though I lay in bed at midnight with my curtains drawn; but now I have been well for many years, though I am apt to think that if I durst venture my eyes, I could still make the phantasm return by the power of my fancy." *

Appendix D.

Amongst the reflections excited in the mind of the great poet (Milton) by his blindness, the following are not the least remarkable for their sublimity, and the spirit of resignation which they breathe.

"Whatever," says he, "I have written, yea at any time, (since the royalists in their exultation imagine that I am now suffering for it by way of atonement, as they will have it,) I call

* Brewster's Philosophical Journal, vol. xiv.

God to witness that I have written nothing which I was not persuaded at the time, and am still persuaded, was right and true, and pleasing to God; and this without being moved by ambition, by lucre, or by glory; but solely a sense of duty, of grace, and of devotion to my country; that, above all, I have done this with a view not only to the deliverance of the Commonwealth, but likewise of the Church. Hence, when that office against the royal defence was publicly assigned to me, and at a time when not only my health was unfavourable, but when I had nearly lost the sight of my other eye; and my physicians expressly foretold, that if I undertook the task I should in a short time lose both—in no wise dismayed at this warning, methought it was no physician's voice I heard—not the voice even of Æsculapius from the shrine of Epidaurus—but of some diviner monitor within. Methought that by a certain fatality in my birth, two destinies were set before me, on the one hand blindness, on the other duty—that I must necessarily incur the loss of my eyes, or desert a sovereign duty. Hence I thought with myself, that there were many who purchased a less good with a greater evil; for instance, glory with death. On the contrary, I proposed to purchase a greater

good with a less evil: namely, at the price of blindness only, to perform one of the noblest acts of duty: and duty being a thing in its own nature more substantial even than glory, ought on that account to be more desired and venerated. I decided therefore, that as the use of light would be allowed me for so short a time, it ought to be enjoyed with the greatest possible utility to the public. These are the reasons of my choice—these the causes of my loss. Let the slanderers then of the judgments of God cease their revilings; let them desist from their dreamy forgeries concerning me; in fine, let them know that I neither repine at, nor repent me of my lot: that I remain fixed, immoveable in my opinion; that I neither believe, nor have found that God is angry; nay, that in things of the greatest moment I have experienced, and that I acknowledge, his mercy, and his paternal goodness towards me; that above all, in regard of this calamity, I acquiesce in his divine will, for it is He himself who comforts and upholds my spirit—being ever more mindful of what he shall bestow upon me than of that he shall deny me; last of all, that I would not exchange my own consciousness of what I have done, for any act of theirs however well performed, or lose the recol-

lection of it, which is always so calm and delightful to me. As to blindness, I would rather at last have mine, if it must be so, than either theirs, More, or yours. Yours, immersed in the lowest sense so blinds your mind, that you can see nothing sound or solid: mine, with which you reproach me, deprives things merely of their colour and surface; but takes not from the mind's contemplation whatever is real and permanent in them. Besides, how many things are there which I should choose not to see: how many which I might be unwilling to see: and how few remaining things are there, which I could desire to see! Neither am I concerned at being classed, (though you think this a miserable thing,) with the blind, with the afflicted, with the sorrowful, with the weak; since there is a hope that on this account I have a nearer claim to the mercy and protection of the Sovereign Father. There is a way, (and the Apostle is my authority,) through weakness, to the greatest strength. May I be one of the weakest, provided only in my weakness, that immortal and better vigour be put forth with greater effect: provided only in my darkness the light of the Divine countenance does but the more brightly shine: for then I shall at once be the weakest and the most mighty; shall be at

once blind and of the most piercing sight. Thus, through this infirmity shall I be consummated —perfected: thus through this darkness should I be enrobed in light. And in truth we who are blind, are not the least regarded by the Providence of God; who, as we are the less able to discern any thing but himself, beholds us with the greater clemency and benignity. Woe be to him who makes a mock of us! Woe be to him who injures us! he deserves to be devoted to the public curse. The divine law, the divine Saviour, has made us not merely secure, but as it were sacred, from the injuries of men: nor would seem to have brought this darkness upon us, so much by inducing dimness of the eyes, as by the overshadowing of heavenly wings: and not unfrequently is wont to illumine it again when produced, by an inward and far surpassing light. To this I attribute the more than ordinary civilities, attentions and visits of friends: of whom there are some with whom, as with true friends, I may hold the dialogue of Pylades and Orestes. For they do not suppose that by this misfortune I am rendered altogether a nullity: they do not suppose that all which belongs to a man of sense and integrity is situated in his eyes. Besides, as I am not grown

torpid by indolence, since my eyes have deserted me, but am still active, still ready to advance among the foremost to the most arduous struggles for liberty: I am not therefore deserted even by men of the first rank in the state. On the contrary, such men, considering the condition of humanity, show me favour and indulgence as to one who has completed his services; and readily grant me exemption and retirement. They despoil me of no dignity, they deprive me not of any public office I before held; they disparage not the benefit which may have accrued from that particular service: and though they are aware that they are now to confer their favours upon one who is become less useful, they think it ought to be done with no less benignity: indeed, with the same honour as if, like the Athenians of ancient times, they had decreed a maintenance for me in the Prytaneum. Thus, while I can derive consolation in my blindness both from God and man, let no one be troubled that I have lost my eyes in an honourable cause; and far be it from me to be troubled at it; far be it from me to possess so little spirit as not to be able without difficulty to despise the revilers of my blindness, or so little placability as not to be able, with still less difficulty, to forgive them."

The astronomer Galileo shared with the great poet in the calamity of blindness. The following circumstances are related by Sir D. Brewster.*

" Although his right eye had for some years lost its power, yet his general vision was sufficiently perfect to enable him to carry on his usual researches.

" In 1636, however, this affection of his eye became more serious, and in 1637 his left eye was attacked with the same disease. His medical friends at first supposed that cataracts were formed in the crystalline lens, and anticipated a cure from the operation of couching. These hopes were fallacious. The disease turned out to be in the cornea, and every attempt to restore its transparency was fruitless. In a few months the white cloud covered the whole aperture of the pupil, and Galileo became totally blind. This sudden and unexpected calamity had almost overwhelmed Galileo and his friends. In writing to a correspondent he exclaims, " Alas ! your dear friend and servant has become totally and irreparably blind. These heavens, this earth, this universe which by wonderful observation, I had enlarged a thousand times be-

* Martyrs of Science, p. 107.

yond the belief of past ages, are henceforth shrunk into the narrow space which I myself occupy. So it pleases God, it shall therefore please me also."

His friend, Father Castelli, deplores the calamity in the same tone of pathetic sublimity:

"The noblest eye," says he, "which ever nature made, is darkened—an eye so privileged, and gifted with such rare powers, that it may truly be said to have seen more than the eyes of all that are gone, and to have opened the eyes of all that are to come!"

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